NATURE

No. 4149 SATURDAY, MAY 7, 1949 Vol. 163

CONTENTS

	Page
Western Civilization and Freedom of Thought	701
Oscillating Stars. By Prof. E. A. Milne, M.B.E., F.R.S.	703
Science in China. By R. Brightman	704
Science for the Layman. By T. H. Hawkins	704
Democritus of Abdera. By L. Roth	705
Veterinary Protozoology. By Dr. G. Lapage	705
Non-Linear Wave Motion. By M. J. Lighthill	706
Lightning and Spark Phenomena. By Dr. T. E. Allibone, F.R.S.	708
The History of Alum. By Prof. J. R. Partington, M.B.E.	710
Obituaries :	
Dr. A. D. Imms, F.R.S. By Dr. W. H. Thorpe	712
Mr. W. A. Knight. By Prof. John Read, F.R.S. ; L. J. F. Brimble	713
Mr. J. Hornell. By R. S. Wimpenny	714
News and Views	714
Letters to the Editors :	
Radioactive Phosphorus in Biochemical Research.—Dr. W. D. E. Thomas and Dr. D. J. D. Nicholas	719
Effect of Enzyme Inhibitors on the Genesis of Phage.—Dr. J. W. Czekalowski and Dr. D. E. Dolby	719
Difference between Morphine and Synthetic Analgesics in their Actions on Ganglionic Transmission.—Dr. C. O. Hebb and Dr. H. Konzett	720
Sympathin.—Dr. G. B. West	721
Phloroglucitol Diammoniacate, $C_6H_3(OH)_3.2NH_3$.—Per Andersen and Prof. O. Hassel	721
Structure of Polyglycine.—Prof. W. T. Astbury, F.R.S.	722
Refining of Oils Containing Vitamin A.—L. Hartman	722
Explosive Decomposition of Ethylene Oxide.—Dr. J. H. Burgoyne and F. A. Burden	723
Stability of Chelate Complexes.—H. Ackermann, J. E. Prue and Prof. G. Schwarzenbach	723
Formation and Decomposition of Ferrous $\alpha\alpha'$-Dipyridyl.—Dr. P. Krumholz ; J. H. Baxendale and Philip George	724
A Co-operative Transition in a Mixed Ketone Shown by a Change of Dielectric Constant.—Dr. Vera Daniel	725
Water Layers in Vermiculite.—Dr. G. F. Walker	726
Sublimation in Outdoor Air and Seeded Sublimation.—B. H. Cwilong	727
Radar Observation of Heavy Rain.—R. F. Jones	728
Frictional Electrification of Dust and Pre-ignition in the Hydrogen Engine.—R. O. King, W. A. Wallace and Edwin J. Durand	729
The 'Complex Indicatrix'.—Dr. A. F. Hallimond	729
Root Nodules of Bog Myrtle or Sweet Gale (*Myrica Gale* L.).—Dr. G. Bond	730
Preparing for the Occurrence of New Races of Rust.—Dr. I. A. Watson	730
Effect of Crude Benzene Hexachloride on Wheat Seedlings.—Dr. B. Hocking	731
Persistence of Pyrethrins and Gamma Isomer of Benzene Hexachloride.—H. H. S. Bovingdon	731
A Rotating Test-Tube Apparatus for Experimental Fermentations.—P. B. Baker	732
Another Little-known History of Botany.—Prof. Jules Brunel	732
The Oil-Drop Method for the Determination of the Electronic Charge. By Dr. V. D. Hopper	733
Action of Suramin on Enzymes. By Dr. B. W. Town, E. D. Wills and Prof. A. Wormall	735
Density of Heavy Water. By Prof. Tsing-lien Chang and Lü-ho Tung	737
Mathematical Association : Annual Meeting	737
A New Fossil Gymnospermous 'Ovary'	738
European Corn Borer in North America	739

Editorial and Publishing Offices
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831
Telegrams: Phusis Lesquare London

Advertisements should be addressed to
T. G. Scott & Son, Ltd., Talbot House, 9 Arundel Street, London, W.C.2
Telephone: Temple Bar 1942

The annual subscription rate is £4 10 0, payable in advance, inland or Abroad

All rights reserved.

Registered as a Newspaper at the General Post Office

WESTERN CIVILIZATION AND FREEDOM OF THOUGHT

"THE scientific outlook and scientific power increasingly dominate our age," writes Mr. John Bowles in his recent book "The Unity of European History"; and, in words strongly reminiscent of those used by H. A. L. Fisher in "A History of Europe", Mr. Bowles continues: "but unless traditional humanist values can be adapted and preserved, the progress of science will be empty and catastrophic. The study of the European past demonstrates the unity of Western culture, the values of the Christian and the Humanist tradition and the pernicious limitations of nationalism and class war. In the light of such knowledge, science can build a society which combines the power of modern technique with the spiritual depth of old experience." Mr. Bowles's political and cultural survey is written largely around a sentence of Mr. Winston Churchill's speech at The Hague Congress of Europe on May 7, 1948, as text: "We shall only save ourselves from the perils which draw near by forgetting the hatreds of the past, by letting national rancours and revenges die, by progressively effacing frontiers and barriers which aggravate and congeal our divisions, and by rejoicing together in that glorious treasure of literature, of romance, of ethics, of thought, and of toleration belonging to all, which is the true inheritance of Europe". To the scientific element in that inheritance Mr. Bowles possibly does less than justice, particularly to its cultural and political significance. Nevertheless, his book displays the vitality as well as the success of European civilization, and he shows clearly how much we have to learn from past ages as to the real nature of the dangers that threaten us to-day.

Like the Russian historian, Restovtzeff, Mr. Bowles sees in the failure of the upper class in the Roman world to extend their culture to the rural and the urban proletariat the fundamental cause of the decline of ancient civilization; and he observes that civilization is dependent on an individual creative genius, on the maintenance of a favourable environment for its realization and upon the preservation of intellectual standards. "No more than Græco-Roman society can modern society continue stable unless the masses participate in the minority culture without lowering its quality. It is the cardinal task of modern civilisation to preserve such standards, to democratise culture without debasing it, to transmit a modernised version of traditional values to the masses and to create a public opinion which respects knowledge."

The recurring theme throughout the book is that freedom of thought and the Christian respect for the individual are the very roots of European civilization, and Mr. Bowles shows from what diverse sources the tradition is derived. He quotes Spinoza that "the ultimate aim of government is not to rule by fear . . . but to free men from fear . . . to enable men to develop their minds and bodies in security and to employ their reason unshackled"—words which are strangely pregnant again to-day; and on the other hand, he shows the evil that flowed from Hegel's

attack on individual rights and impartial law. He brings out, too, the way in which the increase in population, the intricate world-wide structure of modern industry, the revolution in transport and so on have made imperative a planned international and economic order.

Even where Mr. Bowles simplifies too much, he rarely fails to show that the outstanding characteristics of Europe have been freedom and initiative, reflecting a fortunate environment, and that from this enterprise have flowed a brilliant and diverse culture and unprecedented scientific power, the immense advantage of which Western Europe has enjoyed over the rest of the world through its long lead in scientific and industrial techniques. He does not rest content with stressing the dependence of the democratic way of life for its continuance on a co-ordinated drive to ensure self-government and the rule of law in national and international affairs which will guarantee freedom from fear; with the planning of economic life to ensure freedom from want; with the maintenance of freedom of worship, thought and speech. He also points to definite responsibilities in this field on the part of professional organisations.

The vitality needed to deal with contemporary dangers, Mr. Bowles reminds us, can only be maintained by preserving the widest freedom of thought. Such freedom has been the secret of all the great creative epochs, as of modern science itself, and with it now must go the maintenance of independent professional organisations, strong enough to influence public opinion and the policy of the State, and uniting professionally competent experts in a common front. If this freedom and unity can exist, a creative civilization can continue: the alternative is totalitarianism.

Mr. Bowles thus regards professional organisations as possessing the same vital functions for civilization that were visualized by Sir A. M. Carr-Saunders and P. A. Wilson in their study of the professions published some sixteen years ago. They saw vocational associations, with the emphasis shifted from mere organisation to vocation or service, as providing professional men with permanent anchorage and shelter, from which secure positions they could set out to shape organisations into instruments for the fulfilment of their purposes. Carr-Saunders and Wilson had then sensed something of the oppression which the rising totalitarian systems were to exert, and of the need for democracy to brush away inefficiency and organise a free society for the good life. The years between have emphasized the continuing reality of that threat, and the dependence of progress upon a minority of creative minds functioning in an environment of freedom of thought and utterance.

To maintain intellectual standards and the intellectual freedom in which alone they can be preserved is a first responsibility of all professional associations. Some such bodies have always had special responsibilities in this matter, and have rarely for long been unmindful of them. Dr. A. Mansbridge noted, for example, in "The Kingdom of the Mind", that all the old universities of Europe represent historically the development of communities for common interest and protection in the pursuit of learning; and, above all things, their story is the story of European unity and citizenship. Recognition that the universities and professional institutions have a part to play in the defence not merely of freedom of expression but even of freedom of thought itself, should not lead us to overlook their continuing contribution to European and indeed world unity. Moreover, the conditions in which alone science and scholarship can flourish, or even exist, are those where respect for truth and respect for persons are inherent in the general social tradition.

The essential basis of unity for Western Europe is not a political creed but a belief in all the principles linked with an indispensable principle of liberty, and the defence of that liberty is not primarily a political issue but a responsibility resting on all such institutions as universities and professional associations as well as religious bodies. Moreover, as Prof. R. B. Goldschmidt recently emphasized, it is only in the last two decades that there has been any serious interference with the freedom of science by Governments. There have always been organised groups of different types who clamoured for such interference, but in the nineteenth century even the worst reactionaries did not go so far as to abolish the freedom of teaching. Incidentally, Prof. Goldschmidt takes the same view as Sir Robert Robinson, in his presidential address last year to the Royal Society, that in Great Britain the immediate danger to the freedom of science is less of direct attack than of relative depreciation of fundamental research in comparison with technological applications. The body scientific can only flourish when all its organs are in a healthy condition, and where there is a social tradition which respects truth, even abstract truth, for its own sake.

The most important chapter in Prof. G. S. Ghurye's recent book, "Culture and Society"*, is that in which he deals with this question, and more generally with the part the universities have to play in creating and maintaining civilization and culture at a high level. Just how high cultural values are to be created and maintained, or how the passive practitioners of culture are to turn civilization into culture, he does not indicate; but very clearly he regards it as primarily a task to which the universities must contribute the inspiration. He recognizes that there are potentialities in planning which tend to work against individual development and realization; and that a planning society, if it cares for civilization and culture, must strengthen its universities. He reminds us that it is the business of social organisation to provide conditions wherein individuals can realize themselves to the fullest; while the strengthening of the universities involves both full autonomy in the body politic and redressing the balance of studies, now tilted heavily in favour of science and technology, so that the humanistic studies are adequately developed.

Here Prof. Ghurye is positive and emphatic, and although his otherwise somewhat discursive survey

* Culture and Society. By Prof. G. S. Ghurye. (University of Bombay Publications, Sociology Series No. 1.) Pp. x+237. (Bombay and London: Oxford University Press, 1947.) 30s. net.

of nineteenth- and twentieth-century thought gives no clear answer to the questions: "What is culture?", and "What is civilization?", he may well have helped his readers to find their own answers. His book should correct some shallow thinking. Like Mr. T. S. Eliot, he recognizes that the whole of European culture is largely the product of Christianity. Like Mr. Eliot, too, he urges the maintenance of standards and the return to the study of those subjects by which the essentials of culture are transmitted; but he shows something which Mr. Eliot does not, namely, the seed of faith in our humanity. Prof. Ghurye has not entirely lost that faith in the power of man to preserve the best of his old culture while creating from his own spirit a new culture. He demonstrates anew the relevance of much of the thought of Whitehead, Russell and others to this problem of the nurture of a free culture in which creative thought is possible, and the vital necessity of free institutions under a democratic regime. Though he touches only the fringe of the political field, the implication is plain: that the universities, professional associations and the learned societies must take thought and care that the life of the society in which they are placed is not so ordered as to preclude the essential conditions for their work.

An immense responsibility thus rests on the universities and the professional bodies, including the learned societies; but it carries no implication that scientific men and other scholars are inherently qualified to be the saviours of society. They must, indeed, meet the fresh threat, wherever it comes from, to their right to declare and sustain by argument what they believe to be true, a right which has long been the condition of the whole intellectual life of Western Europe. On the right to make and test hypotheses through observation and experiment, to proclaim freely and discuss the conclusions to which inquiry leads, there can be no compromise. When that way is imperilled, scientific workers are bound to join, with fellow men of learning and of every walk of life, to safeguard the continuance of those free institutions through which the great heritage of Western culture has flowed, or they repudiate the very spirit and method of science.

OSCILLATING STARS

The Pulsation Theory of Variable Stars

By Svein Rosseland. (International Series of Monographs on Physics.) Pp. viii+152. (Oxford: Clarendon Press; London: Oxford University Press, 1949.) 18*s.* net.

CEPHEID variable stars—the name given to stars which behave like δ Cephei—have played a distinguished part in modern astronomy. Their most characteristic feature—that there is a definite relation between period and median absolute luminosity—was discovered by Miss Leavitt in 1912 when investigating the Lesser Magellanic Cloud. Owing to this relation, the measurement of period and apparent magnitude allows one to compare the absolute and apparent luminosities, and so affords a reliable estimate of distance, once the zero point of the period-luminosity curve has been fixed. In this way, Shapley determined the distances of the globular clusters, and Hubble determined the distances of the extra-galactic nebulæ.

This would be sufficient glory for any ordinary type of star, but Cepheids have other claims to distinction. Originally supposed to be close binaries in virtue of the periodic shifts in their spectral lines, they were identified by Shapley in 1914 as stars in a state of pulsation, and it was Eddington's attempt in 1917 to give Shapley's hypothesis a precise mathematical form that led Eddington to investigate the equilibrium of non-pulsating stars as a norm, and so to put forward his celebrated theory of the radiative equilibrium of the stars. In another direction, the slow secular decrease in the periods of Cepheids led Eddington to an estimate of the rate of stellar evolution. Since then, their intriguing features have led a host of observers to make refined observations of their light-curves and velocity-curves, and a host of mathematicians to elaborate the pulsation hypothesis.

For several years now, Prof. S. Rosseland, of Oslo, and his co-workers have been engaged in studies of solar and stellar hydrodynamics, and the present admirable volume from his pen gives a detailed account of the application of hydrodynamics to the case of stellar pulsations. It contains not only the classical pioneer investigations of Eddington, but also the less well-known recent researches of the American and Dutch schools, together with many hitherto unpublished results of Rosseland himself. The whole book is written in a most attractive style. Rosseland uses his earlier experience in the analytical dynamics of the quantum theory to put the theory of radial pulsations of spheres of gas into canonical, Hamiltonian form, and exhibits it as a branch of the grand theory of oscillations of dynamical and thermodynamical systems. The issues are thus presented in a form which will appeal by its generality to a large class of readers over and above those professionally interested in variable stars.

Almost every theoretical astrophysicist has had a shot—many of them substantially more than a shot—at solving the outstanding problems which Cepheids offer on the pulsation hypothesis, such as the skewness of the velocity- and light-curves, and the coincidence of maximum luminosity with maximum velocity of approach of the stellar surface. The full bibliographical references given by Rosseland make the reader realize how great a loss the subject suffered through the early death of Woltjer, the Dutch astronomer; and what important contributions have been made recently by Martin Schwarzschild, son of one of the fathers of astrophysics, by Ledoux, the Belgian worker, by Miss Kluyver and Wesselink in Holland, by Biermann in Germany, and by Cowling in Great Britain.

What is the present position of the pulsation hypothesis? Rosseland chooses the wise course of not advocating any particular form of the hypothesis; but attempts to bring out the real difficulties involved and to develop general methods of attack capable of application whatever new observational features the future may have in store. To me it seems that the well-tried methods fail on the whole to account for the phase-relation in Cepheids. It seems incredible that the various causes of phase-lag treated by Rosseland and others should accumulate up to exactly a quarter-period, or that combinations of

higher harmonics, or anharmonics, should yield simultaneously the observed asymmetry of the light-curve and the clear but unexpected phase-relation of the light-curve to the velocity-curve.

Rosseland nowhere mentions what appears to me to be the most striking feature of the observed oscillation, *qua* oscillation, namely, that in the course of the complete oscillation the star never passes through its associated equilibrium configuration—it cycles around it. This is utterly unlike the behaviour of oscillating systems in mechanics. Rosseland gives short shrift to my attempt to *begin* with the energetics of the oscillation, urging that since the solutions have not been derived so as to satisfy the hydrodynamical equations of motion, they need not represent mechanically possible motions. But 'mechanical' solutions have, on the whole, failed to represent the phenomenon. It might equally be urged against the mechanical solutions that the adiabatic hypothesis on which they are based is, as applied to a star, self-contradictory; for if the star is imagined to consist of adiabatically-walled cells of material, the normal flow of energy through the star, which maintains the luminosity, would also be inhibited. The solution in terms of energetics gives at once the asymmetry of the light-curve.

However that may be, Prof. Rosseland is to be congratulated on having produced an entrancing study of an entrancing subject, and on having opened far-stretching vistas in the mechanics and thermodynamics of oscillation theory. It may be added that the book is not confined to Cepheid variables, but treats also of long-period variables, cluster-type variables, variables of special types and novæ.

E. A. Milne

SCIENCE IN CHINA

Science Outpost

Papers of the Sino-British Science Co-operation Office (British Council Scientific Office in China), 1942–1946. Edited by Joseph Needham and Dorothy Needham. Pp. 313+24 plates. (London: Pilot Press, Ltd., 1948.) 25*s*. net.

THE core of this book consists of a series of articles on science in China which originally appeared in *Nature* during 1943–46. With them are reports on the first three years working of the Sino-British Science Co-operation Bureau (February 1943–February 1946), a broadcast from London called "Science and Life in Wartime China" (December 1944), Dr. J. Needham's original memorandum from Chungking on an International Science Co-operation Service (July 1944), and a reprinted paper on the Chinese contribution to scientific humanism. The original part of the book comprises the excerpts from letters, extracts from the logs of the north-west journey in 1943, of a journey on the Burma road in September 1944, of the south-east journey in April 1944 and of a journey in Shensi in October 1945, entries from the diary of Mrs. Needham, and a number of poems by Rewi-Alley, with two by Dr. Needham himself.

To this vivid material, in which the warm human sympathies of the Needhams are so clearly if unobtrusively displayed, the book owes its charm. Of the poems, no more need here be said than that Dr. Needham's "Poem for a Chinese Friend" and the translation of "The Ballad of Meng Chiang Nu" appear to convey the Chinese atmosphere most clearly. For the rest, the poems are less successful than the extracts in displaying the conditions under which the staff of the Sino-British Science Co-operation Office worked during these years, and the background against which the scientific workers and technologists of China sought to maintain and develop the ancient civilization of their country. An excellent series of illustrations contributes to the same end, while the list, which is appended, of 139 papers by Chinese men of science transmitted by the Office for publication in the West, shows that the flow of knowledge through the Office was from East to West as well as West to East.

As a travel book it should appeal to both the scientifically trained and the layman. Dr. and Mrs. Needham have compiled it to do justice to the achievements of the scientific workers and engineers of China. The book may have some further interest as giving, in a modest way, some indication of what is at stake in the present struggle in China, at least so far as science and technology are concerned. But it may, perhaps, take a more permanent place in the literature of science as a simple record of the human values of pertinacity, courage and sympathy on which the achievements of the Sino-British Science Co-operation Office are firmly based and which are demanded as the price of service no less in the field of science than in other fields of human endeavour.

R. Brightman

SCIENCE FOR THE LAYMAN

Into the Atomic Age

By Chapman Pincher. Pp. 158 + 36 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1948.) 9*s*. 6*d*. net.

A Study of Fishes

By Chapman Pincher. Pp. 304. (London: Herbert Jenkins, Ltd., 1948.) 15*s*. net.

A LITERARY problem which does not become less difficult with the increasing complexity of science is that of presenting recent discoveries in a form which is intelligible to the layman. Usually, when an author announces that he is writing a popular book on a scientific topic for the layman, it means that he is either writing a non-specialist book which will be of general interest to the specialist in some other subject, or he is writing a book which will capture the fancy of the general reading public because of the intrinsic interest of the subject itself.

It is to these two groups that Mr. Chapman Pincher appeals with his "Into the Atomic Age". As scientific correspondent to the *Daily Express* he has learned that the majority of his readers are more interested in bits of information about scientists and their lives than about science itself and, in his book, he has carefully blended some straight reporting on the theoretical, technical and military aspects of atomic energy with accounts of meetings he has had with leading atomic scientists in the course of his work. The lay reader is thus carefully led along the road where developments in atomic energy have been made by stages where stiff climbs on technical matters alternate with rests in which information about great men and their careers can be given. The whole book

suggests that Mr. Pincher has not only studied his subject and the art of putting it over, but also the public whom he is trying to reach.

There is also a third group of the reading public for whom the scientific author tries to cater. This is the laity with strong interests in a particular hobby or craft and who are always keen to extend their knowledge of the hobby or craft. In "A Study of Fishes", Mr. Pincher sets out to provide scientific information for the angler which will add to his understanding and, by replacing some of the theories which rely more upon imagination than objectivity, improve his technique on the bank or shore. The book is thorough and contains much that will help the fisherman to understand practical points which he has picked up by experience and hearsay. It is doubtful if the author is wholly successful, however, for whereas topics like the bending of light, the dyeing of maggots, and streamlining should present no great difficulty, sections on breeding and pigments with strange words like genes and chromosomes and peculiar chemical formulæ of substances like melanin might prove to be very disconcerting. The frequent use of American names like killifish and squeteague is equally disturbing, and, although the name and usual location of strange fish can be found in a well-prepared list at the back of the book, the general reader is usually not adept at making frequent references to another part of the book. For him this is meant to be a work to read and not an encyclopædia. If these defects are eliminated in subsequent editions, there is little doubt that "A Study of Fishes" will become a book read and valued by many anglers.

T. H. HAWKINS

DEMOCRITUS OF ABDERA

Le dottrine di Democrito d'Abdera
By Federigo Enriques e Manlio Mazziotti. Pp. xxii + 339. (Bologna: Nicola Zanichelli, 1948.) 1,500 lire.

FEDERIGO ENRIQUES, whose death at the age of seventy-one occurred in 1946, was one of the leading Italian mathematicians of our time; he is specially renowned for his joint creation, with Castelnuovo, of the invariantive theory of algebraic surfaces, which will remain one of the glories of Italian mathematics. As an example of versatility, moreover, Enriques was outstanding; for, over and above his purely technical achievement, which suffices to place him in the front rank, he maintained a lifelong interest in the history and problems of science which, in the "Encyklopädie", his books and articles on one hand, and in his lectures at Bologna and Rome on the other, earned him a second reputation. Above all, he was attracted to speculation concerning the Greek contribution to science, partly, no doubt, because the fragmentary nature of the evidence leads to fascinating conjecture.

At his death Enriques left two completed manuscripts, one (in course of publication) on the theory of surfaces, and the other on the atomist Democritus of Abdera (*c.* 500 B.C.). Knowing the man, one can readily appreciate the appeal of this theme—the reconstruction and interpretation, from stray sentences and commentators' allusions, of the thought of a philosopher whom Enriques esteemed among the greatest of the Greeks. The difficulty of the task is increased by the fact that no one can be sure how much of the fragments remaining to us is due to Democritus and how much to his master, Leucippus.

Like much of Enriques's work, the book is a collaboration, in which the arrangement and interpretation of the text is due to Dr. Mazziotti, the superstructure being largely Enriques's own. Each chapter deals with a particular aspect of Democritus's contribution to philosophy; it opens with a detailed and acute critique of the subject-matter from the modern scientific point of view, after which come the various classical texts (in Italian translation), accompanied, wherever necessary, by brief comment or explanation. All this material is arranged in thirteen chapters, which cover the whole field of Greek thought, from natural science and geometry to biology, logic and ethics. The masterly comments can be read and enjoyed for their own sake, irrespective of their bearing on the historical and technical problems which the author seeks to elucidate; and the book should, therefore, reach a wide circle of readers.

L. ROTH

VETERINARY PROTOZOOLOGY

Veterinary Protozoology
By Prof. Banner Bill Morgan and Prof. Philip A. Hawkins. Pp. vii + 195. (Minneapolis, Minn.: Burgess Publishing Co., 1948.) 4 dollars.

THIS book has been written for veterinary students, practising veterinarians and agricultural students, and its scope is similar to that of U. F. Richardson's book reviewed recently in these columns (*Nature*, **162**, 756; 1948). It is a useful book, full of practical information; but the size of its page (11 in. × 8¼ in.) makes it rather inconvenient to handle, and its small type, clear though it is, is not read with comfort on a page of this size. Its illustrations, with the exception of the frontispiece, are all in line and stipple, and are all unusually large. Many of them are so much simplified that they lose much of their value. One cannot help thinking that a reduction of their size would have made a smaller page possible and would have released space for more of the useful text.

One doubts, for example, whether any reader will require a *Tritrichomonas* four inches in overall length; or coccidian oocysts on a similar scale, which do not show the spores and residual bodies which are essential if the figures of the oocysts are to be aids to diagnosis of the species. Photographs of oocysts are used in other books, and they give a much better idea of what is actually seen through the microscope. The frontispiece, a microphotograph of *Tritrichomonas fœtus* magnified until it reaches an illustrated length of 7¼ inches, cannot be called a satisfactory representation of this species, and the diagrams of it printed elsewhere in the book are more useful.

The text of the book contains a great deal of valuable information. It begins with a brief general account of the Protozoa, which might have been more carefully worded. Of the Sporozoa, for example, the authors say that "Reproduction is by schizogony (spore formation)", a phrase which fails to distinguish between the asexual process of schizogony and the formation of spores after a sexual process. A similar failure to supply the biological basis of the veterinary specialist's work is evident in the statement that

"Reproduction" of the Ciliata "is mainly by conjugation; asexual reproduction by binary fission occurs"; and in the definition of the reservoir host as "a host harboring parasites which may be transferred from man to domestic animals", a statement which is inadequate even in the restricted field of veterinary protozoology.

Criticisms of this kind do not, however, apply to the greater part of the book, which gives a detailed and valuable account of the Protozoa that cause diseases of farm stock, and of the symptoms, diagnosis and treatment of these diseases. The hosts considered in turn are horses, cattle, sheep and goats, swine, dogs, cats and the 'fur-bearers', namely, the fox, rabbit and mink. *Tritrichomonas fœtus* and the disease it causes receive considerable attention, and there is, at the end of the book, a diagram of a plan for hygienic breeding designed to eradicate bovine trichomoniasis and also, in the useful section of the book on diagnosis of protozoal infections, a large plate of diagrams of Protozoa likely to be encountered when trichomoniasis is being diagnosed. Another plate illustrates the not very complex instruments used by the authors for diagnostic work. Some of the space given to these plates might well have been given to structures, such as seeds and fragments of various kinds of foods, which may resemble coccidian oocysts and dying or degenerate Protozoa in the fæces. Even a reduction in size of the figures would have made this possible.

Workers who have difficulty in obtaining the literature of this subject will find a good summary of it in this book, and also a bibliography, extending to 18 pages, which includes important books, a list of the circulars and bulletins on protozoal diseases issued by the United States Bureau of Animal Industry and Department of Agriculture respectively, as well as references to 309 research papers. There are also useful host-parasite lists, schedules of treatment and a brief article on the International Rules of Zoological Nomenclature.

G. LAPAGE

NON-LINEAR WAVE MOTION

Supersonic Flow and Shock Waves

By R. Courant and K. O. Friedrichs. (Pure and Applied Mathematics, a Series of Texts and Monographs, Vol. 1.) Pp. xvi+464. (New York and London: Interscience Publishers, Inc., 1948.) 42*s*.

TWENTY-FIVE years ago what was known on the dynamics of gases, if acoustics and the study of steady motion at speeds small compared with that of sound (when the flow resembles that of a liquid) be omitted, could have been expounded in a few dozen pages. Since then, and more rapidly since 1943, the subject has grown into one which no single book can describe in its entirety. The primary stimulus was the increase in aircraft speeds; but a secondary stimulus, the belated realization of workers in pure science that the phenomena show fascinating differences from those of classical physics, has become equally important.

Profs. R. Courant and K. O. Friedrichs have not sought to cram into their review of progress in this field a vast mass of detail in an attempt to be comprehensive. They have chosen rather to present certain parts of gas dynamics, in a leisurely style, so as to make the result essentially a study in non-linear wave motion and the propagation of waves of discontinuity; there are appendixes on analogous physical problems, including waves in elastic-plastic materials. Engineers can go elsewhere for rule-of-thumb procedures, for accounts of experimental methods, or for the very extensive and valuable linearized theory of supersonic flow. The man of pure science may regret, however, the almost complete absence of reference to viscosity as an important property of gases.

Prof. Courant is the author of the celebrated "Methoden der mathematischen Physik", Vol. 2, which includes, in a precise and unified whole, a very large mass of general theory relating to partial differential equations. The present book incorporates from that work much of the theory of the quasi-linear hyperbolic problem. The preface regrets that a similar unification and completeness are impossible throughout the present subject, still in its infancy. The reader must rejoice, however, that the authors have not excluded special, more involved, methods which are as yet imperfectly known, since the frontiers of science are often thus isolated, and the interest of the fighting scientific worker lies mostly in such regions. In much of this we see the pen of Prof. Friedrichs, a doughty explorer of new paths.

The book is discursive, and aims principally at communicating the type of mathematical and physical behaviour encountered. It is not a reference work, so it should be read straight through, perhaps fairly fast. The clever student who does this, fresh from an undergraduate course of classical (linear) mathematical physics, will be led safely into a clear understanding of what is now known on the non-linear wave problems involved. Some of the ideas are complicated, and the pages of 'talk', free from formulæ, will be found among the most useful.

Unsteady rectilinear motion is covered very thoroughly, more so than in any previous book, and much of the critical work is done here, since the equations are fairly tractable in terms of Riemann's variables, while the deduced behaviour can mostly be taken over into more complicated systems. This work includes an extensive section on flame propagation.

Plane steady supersonic flow is then treated more briefly; its behaviour is qualitatively almost identical with the unsteady rectilinear motion if the second spatial dimension is equated to the time. The 'limit line' is put firmly in its place (below the importance attributed to it by some); its connexion with the hodograph transformation is displayed, though otherwise the latter is developed only for the purpose of finding simple exact solutions and for the graphical method of Prandtl and Busemann.

Shock reflexion is treated thoroughly. To reconcile theory and experiment on 'Mach reflexion' various postulates put forward include an expansion wave centred at the three-shock intersection. The Laval nozzle is discussed in detail, and it is shown what a variety of shock configurations are possible therein as explanations of phenomena observed in choking and otherwise. A short section on axi-symmetrical flow and spherical waves, 198 references and an index conclude the book.

The book, compiled and improved over a number of years, and given limited circulation in an earlier, shorter form during the War, is most careful and accurate in its statements. However, in Fig. 41 the rear shock should curve in the opposite sense.

M. J. LIGHTHILL

Henry A. Ward, Museum Builder to America

By Roswell Ward. Edited by Blake McKelvey. (Rochester Historical Society Publications, Vol. 24.) Pp. xxiv + 297 + 15 plates. (Rochester, N.Y.: Rochester Historical Society, 1948.) N.p.

PROBABLY no individual has contributed more to the development of natural history museums throughout the world than Henry Augustus Ward, of Rochester, New York, who, even in his boyhood days, had acquired a roving disposition. At an early age he developed a keen interest in geology, and by dint of persistent hard work coupled with exceptional and unexpected opportunities he attained a position of eminence when he was comparatively young.

Early in the second half of the last century his passion for travel and for collecting rare specimens brought him to Europe, where he visited every museum he could find, returning to Rochester at the age of only twenty-seven with the finest collection of geological specimens in America. But this was only the beginning, and his love for exploration and the acquisition of new exhibits lured him to all parts of the world and provided geological and zoological specimens for Ward's Natural Science Establishment, which soon became a great emporium for the distribution of natural science material. Not only was this establishment famous for the provision of outstanding exhibits which led to the formation of many natural history museums, particularly in America, but it also became a training ground of outstanding men in various branches of museum technique who afterwards graduated to positions of eminence in the museum world. The later years of Ward's life were devoted to building up the most complete collection of meteorites in existence, a collection which is now preserved in the Field Museum, Chicago. The biography has been admirably written by his grandson, who has given us a complete and fascinating account of the life, work and achievements of a remarkable man of science, explorer and collector.

H. SHAW

Was ist Wahrheit in den Naturwissenschaften?

Von Bernhard Bavink. Pp. 88. (Wiesbaden: Eberhard Brockhaus Verlag, 1947.) n.p.

IN this little book Prof. B. Bavink discusses first the meaning of 'truth' in science and, secondly, the criterion by which we determine what is true and what is false. On the first point he contrasts the realistic view—that there is an external world which we examine and that our description of it is true if it corresponds faithfully to that world—with the positivist view that there is no world independent of our observations and that a statement about our observations is true if it is consistent with them all. As a compromise between these extremes he cites the Kantian doctrine that there is an external world but that it is unknowable and all our knowledge is of our experience. Prof. Bavink considers these attitudes in their relation to both general and particular scientific laws. Without definitely adopting any of these views he points out that in practice we usually think in terms of the first, and that in any case we must admit that scientific laws hold independently of the knowing subject. In the matter of the truth criterion he discusses the belief that mathematical and scientific theorems are conventions, and gives reasons for rejecting the positivist attitude in this matter. He finds the criterion of truth with respect to a scientific law in the convergence of different, and apparently independent, lines of research towards the same conclusion; the law is true in so far as this convergence is without exception.

While the book does not contribute anything essentially novel to the problems of which it treats, it is clearly and interestingly written, and sets out the various considerations in a thought-provoking manner. It may be recommended as a valuable stimulus to those whose minds are not yet made up on the subject.

H. D.

Einführung in die vergleichende Morphologie der Wirbeltiere

Von Prof. Dr. Adolf Portmann. Pp. 335. (Basel: Benno Schwabe und Co., 1948.) 28 Swiss francs.

DURING the nineteenth century many detailed works on comparative morphology were published, both for vertebrates and invertebrates. At the close of the century, morphology was frowned upon by the eager physiologists, experimental biologists, embryologists and geneticists, who maintained that morphology was worked out. But as usual the pendulum has swung back again, and there has been a realization that morphology is the fundamental study upon which the others are based, and that not less but more is needed.

Prof. A. Portmann's book is an up-to-date treatise on the elements of comparative morphology, based on a wide, accurate and detailed knowledge of the vertebrates. The work follows the usual course, dealing with the systems and organs of the body in turn, discussing their homologies, comparing fossil and modern examples, and assessing the value of their evolutionary trends. The excellent figures prepared by Frl. M. Stehelin are especially to be commended. Their very simplicity is pleasing, and her bold use of black and white is applied with an artistic merit rarely seen in text-books. The parts of diagrams in comparative series are numbered instead of lettered, so that the reader can test his knowledge. Is it to prevent his memorizing the numbers that in one series the numbers begin at the anterior, and in another at the posterior end? A selected list of modern works is intended as an introduction to the literature, and there is an index.

N. B. EALES

Introduction to Emulsions

By George M. Sutheim. Second printing. Pp. viii+260. (Brooklyn, N.Y.: Chemical Publishing Co., Inc.; London: Chapman and Hall, Ltd., 1947.) 21*s.* net.

THIS book is written in the first person in lecture style, and is, in fact, based upon lectures given at the Brooklyn Polytechnic Institute in New York. It is claimed to be written by a practical man for practical men, and, on that account, contains details and explanations which the chemist with a university degree will find superfluous. A bibliography is appended with 159 references; but no mention is made of G. I. Taylor's work on the physics of emulsion formation, nor of F. A. Cooper's work on size frequency analysis and the chemical engineering aspects of emulsion manufacture. Another extensive appendix gives the commercial name of 182 emulsifying agents produced in the United States, and lists their chemical name or formula, group and emulsion type and manufacturer. The uses of bentonite as an emulsifying agent is only lightly considered. The manufacture of a good emulsion is still somewhat of an art, and the comment that "you cannot learn to ride a bicycle by reading a book" still seems to hold for practical emulsion technology.

M. B. DONALD

LIGHTNING AND SPARK PHENOMENA*

By Dr. T. E. ALLIBONE, F.R.S.
Research Laboratory, Associated Electrical Industries, Ltd.

THE study of lightning has been allied to the study of the electrical spark discharge since the dawn of experimental science. Benjamin Franklin, the 'father of lightning', performed with electricity drawn from thunderclouds the same experiments that could be performed with electricity generated by a frictional machine. Hoffert demonstrated the multiple character of the flash by photography in 1889, and a few years later Walter showed that the electric spark could have a similar characteristic if the circuit constants were suitably chosen. In later years Schonland's extensive researches in South Africa, with the aid of the high-speed rotating camera, have greatly extended our knowledge of the lightning flash, and similar physical characteristics to those he has described have been found in the high-voltage spark discharge. Knowledge of both phenomena is, however, far from complete; but as lightning occurs so infrequently in Britain under conditions suitable for observation, it is perhaps more profitable in this country to contribute to the understanding of lightning by the indirect method of studying spark phenomena.

Sir George Simpson[1] made one of these first contributions, from which he deduced the polarity of thunderclouds. He observed the marked difference between the positive and negative streamers which pass between dissimilar electrodes charged from a Wimshurst machine—when the more highly stressed electrode was positively charged, sparks branched away from it; but when negatively charged, strong unbranched discharges passed between electrodes. On examination of more than four hundred photographs of lightning, he found more than 50 per cent exhibited branching away from the cloud and only three towards the cloud; 25 per cent showed unbranched discharges, but he recognized that branches on these might have been obscured by cloud or rain, so that at least a safe generalization was that the majority of flashes emanate from positively charged clouds.

This deduction was directly opposed to evidence of field changes at various distances from lightning flashes; Schonland and Craib[2], Wormell[3] and others following C. T. R. Wilson's pioneer work found the majority of lightning flashes brought a negative charge to ground, and Schonland correlated this with visual observations that a high percentage of these flashes branched downwards from the clouds. He also measured the magnitude of the point-discharge currents beneath a thundercloud and found these to be of such a polarity as to leave a positive space charge over the ground. This conflict of evidence prevailed until 1931, when the matter was resolved by a series of observations of spark discharges from a one-million volt generator in the High Voltage Laboratory of the Metropolitan-Vickers Company. Simpson's observations had been made with perhaps 50–100 kV. sparks; at much higher voltages the difference in appearance between sparks of opposite polarity is not nearly so marked as at low voltages, and frequently extensive branching of a negative discharge can be seen. The conditions for this were determined[4]; if an extensive positive space charge is built up in advance of the negative streamer, the latter will branch just as profusely as will a positive streamer, and then, to a first approximation, no difference can be observed by eye between positive and negative discharges. The fact that Simpson and many others observed a high preponderance of branched lightning discharges does not, therefore, imply that the discharges are of positive polarity.

Two years later, Schonland began his extensive researches into the nature of the lightning discharge as photographed by the Boys camera with rotating lenses. These showed the existence of a low-intensity discharge which travelled slowly from cloud to ground, followed by a high-intensity return stroke from ground to cloud, the speed of propagation of the latter being some 10–100 times that of the 'leader stroke', as Schonland named the pioneer discharge. This time interval between the initial appearance of the leader stroke leaving the cloud and the return of the 'main stroke' to the cloud immediately appeared analogous to the 'time-lag of flashover'[5] of a gap, so familiar to scientific workers engaged in transient electrical researches, and a search for the 'leader stroke/main stroke'[6] sequence in the laboratory with the aid of a rotating film camera was made. Sparks 40 in. in length were photographed with a camera capable of resolving times of the order of one microsecond, and the photographs showed unmistakably that as soon as the high-voltage source was connected to a point electrode, a discharge developed from this to ground, while a few microseconds later a fresh discharge passed between electrodes carrying such a large current that the potential of the point fell to very low value; the oscillograph showed that the 'time-lag of breakdown' was identical with the time interval between the onset of discharge and the occurrence of the main stroke as recorded photographically. Schonland described the leader stroke as a faintly luminous downward-moving streamer travelling with a speed of about 10^7 cm./sec.; when the ionized path is continuous between cloud and ground, a brilliant upward-moving streamer develops from ground to cloud at 10^9 cm./sec. From these early spark photographs and corresponding oscillograms, it was deduced that the leader stroke travelled between the electrodes at about 10^7 cm./sec., but the camera was unable to give information as to the speed of the return stroke.

The above results in the laboratory merely confirmed that sparks behaved in a manner similar to lightning flashes; but they were obtained for positive *and* negative discharges, whereas only negative lightning flashes have been observed with the rotating camera. The laboratory sparks were produced by the discharge of a condenser, and the way they were affected by the circuit constants was studied[7]. It was found that with large values of circuit resistance the 'leader stroke' in its progress from the high-voltage electrode to ground was reinforced intermittently by fresh charges brought from the high-voltage source, the time interval between these stepped processes being a measure of the recombin-

* Friday Evening Discourse at the Royal Institution, delivered on March 12, 1948.

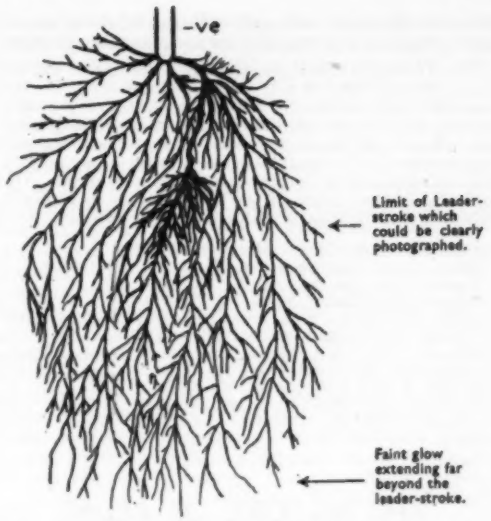
ation of ions. Undoubtedly the stepped process also depended upon the circuit resistance and therefore on the time-voltage characteristic of the applied potential, so that it is arguable that the stepped character of the lightning leader stroke may also be due to the 'resistance' of the current-carrying path within the cloud. More laboratory work is needed to give a better understanding of the advance of the leader stroke.

An interesting difference was found between the positive and the negative discharge[8]. In general, the positive leader stroke progresses most of the way from a high-voltage (positive) point electrode to a grounded plane electrode; but in general as a negative leader stroke progresses from a high-voltage (negative) point electrode, it is met in mid-gap region by a positive leader stroke rising out of the grounded plane. If the field-strength at the positive grounded electrode is artificially increased—as by providing pointed electrodes projecting from the grounded plane—the upward positive leader stroke development is favoured, and the meeting point between the two leader strokes is raised nearer to the negative electrode, until, if the grounded positive point is high enough above the plane in relation to the inter-electrode gap, the positive leader dominates the picture to the almost complete exclusion of the negative leader from the high-voltage electrode. If this is true also for lightning, discharges at the top of high buildings should be predominantly discharges *from* the buildings to cloud[8]; this phenomenon was, in fact, observed from the top of the Empire State Building, New York.

This same characteristic must be the cause of the prevalence of a high percentage of negative discharges being recorded on transmission lines; the advancing lightning flash, if of negative polarity, is 'attracted to' a high tower or line by virtue of the ascending positive leader stroke rising from the line to meet the flash. There are in existence a number of photographs of lightning which provide evidence in favour of this, though no actual record exists taken by a rotating camera of flashes to towers or moderately tall buildings; the deduction is based primarily on the laboratory spark photographs, and the only doubt lies in the exact magnitude of the effect on the statistics of lightning strokes to lines.

Further work by Schonland and his co-workers established the fact that the leader stroke discharge was a complicated process; a streamer develops from the cloud in a series of steps separated in time by about 50 microseconds, and at each step the discharge is advanced towards ground by a discharge path more luminous than the remainder of the discharge; it was suggested by Schonland[9] that the steps were preceded by a 'pilot' streamer, too feeble to photograph, advancing continuously from cloud to ground with a speed of about 10^7 cm./sec. As mentioned above, whether it advances continuously or not may depend on circuit constants, but whether it exists or not is of great interest.

Now it had been known for many years that not even quartz lenses and fast photographic plates could record all the details of a spark which can be seen by eye. For example, in the 1931 experiments[4] on branching of negative discharges, a technique had been used of arresting the discharge by providing in the circuit an alternative spark path having a time-lag of spark-over just a little shorter than the time-lag of the gap under close observation. Under these conditions the great glare of the spark is eliminated



Development of pilot streamers ahead of the 'leader stroke' to the spark discharge

from the gap, across which only a partial spark is developing, and a most extensive tracery of discharge was visible to the eye but not recorded photographically. In a recent effort to establish the existence of the 'pilot' streamer, these old experiments were repeated[10] with a new photographic technique; bromide or gaslight printing paper was set up in a vertical plane between the high-voltage electrode and ground, so that the arrested discharge played over the surface of the paper and left a latent image. This probably was as extensive as any discharge the eye could see; a very extensive fine tracery was recorded many inches ahead of the 'leader stroke' which the rotating film camera could record, and the leader stroke is now discernible, not as a discharge advancing into virgin air, but as a canalizing of the tenuous discharges, possibly when the current density reaches a certain value. The accompanying sketch taken from one of the photographic prints shows the details better than can be brought out by direct reproduction of the original prints. Clearly this tracery could never have been detected in the lightning flash photographs, but it provides very strong evidence for the correctness of Schonland's 1938 postulate of a pilot streamer. With what speed this diffuse discharge advances into the virgin air is not known, nor at what current density the canalization of the discharge occurs; and much more experimental work in the laboratory is needed to take the subject a step further.

Another problem of the thundercloud which can be studied in part in the laboratory is the potential necessary to cause breakdown. Early estimates of potentials of clouds with respect to ground were based on the known breakdown potential of air between pointed electrodes at rather small spacings; but there is insufficient information about the breakdown potentials of very large gaps to say whether the same gradients are necessary for a discharge to start. What information exists relates to impulse voltages, but the breakdown laws under constant voltages would be much more interesting, since breakdown within the cloud must begin by discharge

between oppositely charged volumes of cloud maintaining their charge steadily for some seconds at least.

(The Discourse was illustrated by a number of experiments with a 500,000-volt impulse generator; in the darkened auditorium the positive and negative leader strokes were shown at different stages of development, the influence of electrode shape on leader strokes was demonstrated, and examples of the 'protective action' of a pointed electrode on the space around it were shown. The influence of the nature of the terrain on the incidence of lightning was illustrated with a sand tray model.)

[1] Simpson, *Proc. Roy. Soc.*, A, **111**, 56 (1926).
[2] Schonland and Craib, *Proc. Roy. Soc.*, A, **114**, 229 (1927).
[3] Wormell, *Proc. Roy. Soc.*, A, **115**, 443 (1927).
[4] Schonland and Allibone, *Nature*, **128**, 794 (1931).
[5] Allibone, Hawley and Perry, *J. Inst. Elect. Eng.*, **75**, 671 (1934).
[6] Allibone and Schonland, *Nature*, **134**, 736 (1934).
[7] Allibone, *J. Inst. Elect. Eng.*, **82**, 513 (1938). Allibone and Meek. *Proc. Roy. Soc.*, A, **166**, 97 (1938).
[8] Allibone, *J. Inst. Elect. Eng.*, **82**, 513 (1938).
[9] Schonland, *Proc. Roy. Soc.*, A, **164**, 132 (1938).
[10] Allibone, *Nature*, **161**, 970 (1948).

THE HISTORY OF ALUM

A HISTORY of almost any common material could be made the framework of a general history of civilization, both in its political and economic aspects, and hence could serve as a kind of heuristic method of teaching general history. This would be a very uneconomic method, since every specialist author would have to repeat a large mass of material already traversed by every other author; and it may be suggested that a historian of science or technology might profitably assume that the political history (taking the name in its widest sense) with which his studies bring him more or less intimately in contact can be sought elsewhere. There are notable exceptions to this; some works on the history of science, such as Meyer's "Geschichte der Botanik", deal in detail with various aspects of general history in a way which makes them still very useful to the professional historian when he happens (as is rarely the case) to know of their existence. The history of alum is a subject which lends itself very well to a plan of fitting it into a general picture of the conditions and movements of the times traversed, and an author working up this subject has a good opportunity of doing this if he feels inclined towards it. It may be said that Dr. Charles Singer has, in fact, incorporated a substantial amount of such material, including a general history of the alum trade, in his recently published account*, and this will make it especially valuable and interesting to the general historian.

An author taking up a study of the history of a material will find that his subject will fall into one or other of three large groups. In the first, the basic information is already well known and exists in adequate detail; such, for example, would be the history of iron. In the second, practically no coherent and collected information is available, and the author is compelled to go through an immense number of likely and unlikely sources, assemble a mass of unconnected and generally contradictory statements, and then attempt to reduce the material to some kind of order, carefully avoiding any tendency to arrive at general conclusions before this has been done, so as to prevent the possibility of making a framework into which the material must, at all costs, be fitted. In the third group, the material has already been treated, but imperfectly and often at a date when important information relevant to it was not available. It may be suggested that the history of alum belongs to this third group. Its main outlines have been drawn by such authors as Beckmann and Heyd, and the main sources to which a modern author might turn for his materials have been stated by them. It is then essential to re-examine the data and, in completing it and adding what is new, to draw more correct conclusions. Beckmann, for example, although he makes use of nearly all the material now available, drew a completely incorrect conclusion from it, namely, that alum was unknown in antiquity.

The history of science can be presented in various ways. Those who have read the previous publications of Dr. Singer will be aware of the general guiding principles which he follows, and will know what to expect. An author may confine himself to an account of his subject proper, or he may include what may be called the external machinery of science, such as the foundation and growth of scientific societies, the relation of the personalities with whom he deals with religion or politics, when they happen to have had such relation, and in such cases to deal with these wider aspects of the subject. Some sciences lend themselves more easily to such treatment; astronomy in particular is one, and such personalities as Galileo offer an almost inexhaustible plenitude for repetitious treatment in such a way. This type of writing, however, is more suited to the general historian, or the author who sees in the history of science an opportunity of conveying to his readers, many of whom he may hope are relatively uninstructed, his cherished beliefs or creeds. Such writing is not in the category of history of science proper, and does not advance in any way the study of this subject.

In his publications Dr. Singer has followed a middle path. He has available a wealth of detailed knowledge such as the specialist would use in producing a severely professional account of the subject, and at the same time he has a feeling for the picturesque and attractive marginal aspects, in particular of the value of illustrative material, which make his works so attractive and readable. Much of this material is drawn from little-known and inaccessible sources such as manuscripts or books, the existence of which is unknown to the general historian of science. In the present work, in the preparation of which Dr. Singer has been fortunate in being able to draw on such sources, he has given a selection of illustrations, including many in splendid colour, which puts the book into a class of the highest interest, and makes it, even to those not much drawn to the general story of alum, one which must have a lasting value as a fine book, in the production of which the artistic craftsman has played a notable part. In the appearance of the book, as a book, everyone concerned must take a justified pride. Dr. Singer always takes care to accompany every illustration with an adequate description, and this feature of his authorship is fully continued in his latest work.

The book is divided into five main parts: antiquity, medieval technical and chemical lore, medieval trade, monopolies and empirical methods, and the rise of scientific industry. As stated above, although the guiding theme is the history of alum, an opportunity

* The Earliest Chemical Industry: an Essay in the Historical Relations of Economics and Technology illustrated from the Alum Trade. By Charles Singer. Pp. xviii+337. (London: Folio Society, 1948.) £10 10*s.* 0*d.*

is taken in each section of presenting information from other departments of knowledge, which makes it, in itself, a valuable source for the student of each period as a whole, although the quotations from texts are, in the main, those dealing with alum. There are 361 references collected at the end of the book, an arrangement which, although perhaps necessary on æsthetic grounds, is very inconvenient to the reader in search of information. There has been a tendency among old-fashioned authors, particularly in Britain, to show a degree of shame in exhibiting detailed knowledge; this is perhaps a relic of their own school days, when such accidentals of scholarship were looked upon with disfavour. Such reticence is out of place in modern works on the history of science, when precise documentation is necessary and expected. Dr. Singer, as usual, takes a middle way, giving us in many cases only the title of the work, without a page reference. His bibliography is very satisfactory; only in one or two cases would one have wished for slight additions, as when he refers to D'Arcy Thompson's "Glossary of Greek Fishes" for the murex and omits to mention the special treatise by Moatsou (Alexandria, 1932); but even the narrowest specialist will find himself baulked at every turn in his search for omissions of sources in Dr. Singer's impressive list.

A reviewer is expected to find at least a few faults with every work, and to show good faith to his kind, the present writer will hurry over a few slight trivialities of this sort. The *bain Marie* of the Greek–Egyptian chemists was not a water-bath, and the original figures of the *kerotakis* would have been better than the supposed reconstructions (p. 10); *trichitis* (p. 19) is not alum, as the author knows in another place; *realgar* is not red sulphide of mercury (p. 52); 'saturated alkali' (p. 39) is probably ferrocyanide. Agricola was not a technological expert and cannot be expected to understand all he describes, and his portrait is not contained in any original edition of his book the reviewer has seen (pp. xv and 227); phlogiston is named before Stahl's work of 1703 (not 1702, as stated) (p. 249), and the dephlogisticated part need not be a 'fixed' body—in sulphur it was sulphuric acid; Lavoisier did not think the alkalis were oxides of unknown bases (p. 267); Davy's first name for potassium was 'potasium' (p. 268); Wöhler's aluminium was not very impure, and the metal was also obtained by Ørsted in 1826 (p. 268). These are all trifles. The style of the book is clear, concise and attractive; only in one or two cases has the author been hypnotized momentarily by his text, as in the Germanic "they dyed always the yarn before weaving" (p. 265). The reader should not omit to look up the references, where additional information is often to be found.

The story presented by Dr. Singer is, in brief, the following. Alum was known to the ancient Egyptians and Assyrians, who used it medicinally and in magic. Its use as a mordant in dyeing is described at least as early as Pliny (who, by the way, gives the first record of galls as an indicator long before Fallopia, p. 244), and from that time the history of dyeing is intimately connected with the history of alum, so that the book is valuable to those interested in dyes. It is shown that knowledge of chemical substances in the classical period was much more extensive than is sometimes thought, and not a few, alum notably, were known in quite reasonably pure condition. An account of ancient baths is given. Puteoli (modern Pozzuoli, on the Bay of Naples) was a source of alum, its baths long being famous. The information about technical arts in the medieval period is drawn from several treatises compiled in that period by non-literary authors, giving recipes for dyeing, etc.

After a concise account of Arabic alchemy (in which the strange difference between the "Secret of Secrets", an alchemical work thought to be by al-Rāzī, from his medical works is not noticed), and its continuation as the so-called Latin alchemy, Dr. Singer deals with lapidaries and handbooks such as the "Hausbuch" and the problematical "Plictho". A long and detailed account of medieval trade brings together much information about the rivalry of the Italian centres. In this period the import of alum from the East increased, although European alum, less esteemed than the Asiatic, was still made in significant amount. Exports from the Eastern Mediterranean, Phocæa, and the Black Sea became important, and there is an interesting account of Phocæa in Pegolotti. The rise of Venetian trade under a grant of privileges in the Byzantine imperial domains is linked with the influence of the Crusades. In the fourteenth century Florence had a trading supremacy, and the connexion between alum and wool turned a new corner on the way of technology and trade. Western sources of alum were now productive.

In 1461 large quantities of alunite, a mineral from which alum can be made, were found at Tolfa in Papal territory, and the famous Papal alum monopoly was established mainly by the efforts of Giovanni de Castro and Pope Pius II. The profits of the trade helped to subsidize the war against the Turks. The purchase of 'infidel' alum was anathematized, and indulgences were based on such motives. It is perhaps not generally known that the famous indulgence on which Luther acted was of this character. The monopoly of the Papal alum factory was later broken by the northern countries making alum from other sources. A financial contract between the Medici and the Apostolic Chamber in 1466 began a period when alum was not infrequently mingled with the hopes of mankind for felicity in the hereafter. This story of the Papal monopoly is fairly and clearly told; it had interesting ramifications. The works at Pozzuoli are well described, the illustrations of this volcanic region being most interesting. Some splendid coloured plates are reproduced from the work of Sir William Hamilton, who visited the district in his capacity of British Ambassador to Naples in 1764, as well as an interesting drawing by Madeleine Hortemels (aged seventeen) of the Grotto del Cane in a guide book of 1707. For this source of alum we have the well-known book "Metallotheca" by Michele Mercati (1717).

The working of alternative European sources of alum in the seventeenth and eighteenth centuries is described, with an interesting excursion on the history of mining (which is just beginning to pass out of the second category mentioned at the beginning of this review) and mineralogy, including mineralogical collections and museums. Alchemy was now giving way to chemistry, and for that reason the alum industry, which is perhaps the earliest chemical industry of all, could become scientific. Dyeing also became scientific, and the description of the sources and uses of the natural dyes is one of the most interesting sections of the book. The British alum industry had its rise in the exploitation of the carboniferous shale of the Yorkshire coast and Scotland. Peter Spence (1806–83) was the pioneer of this

industry, and his descendants are among the premier alum manufacturers of the world. The preface of Dr. Singer's book, by Mr. Derek Spence, explains how it was wished in 1946 to celebrate the hundredth anniversary of the company by a lasting memorial to Peter Spence, and the present splendid volume is the result. In achieving their object they have at the same time, thanks to the unrivalled knowledge and literary skill of Dr. Singer, added a lasting contribution to the history of science for which they deserve the warmest thanks of all those interested in its welfare. This book will take its place among the great classics of the subject.

J. R. PARTINGTON

OBITUARIES

Dr. A. D. Imms, F.R.S.

AUGUSTUS DANIEL IMMS, who died on April 3, 1949, at the age of sixty-eight, was well known to zoologists and entomologists throughout the world, and there are few, if any, modern zoological text-books with a wider circulation than his famous "General Text-book of Entomology". Imms graduated at Birmingham in 1903 and shortly afterwards went to Christ's College, Cambridge, as an 1851 Scholar. Here he obtained a B.A. degree by research in the days before the institution of the Ph.D., and came much under the influence of Dr. David Sharp and Sir Arthur Shipley. From being an assistant demonstrator in zoology under Prof. Gamble at Birmingham, he went to India in 1907 as professor of biology in the University of Allahabad. Later he was for three years forest zoologist to the Government of India.

These seven years in India influenced profoundly his further development as a zoologist, adding to his sound morphological attainments breadth of view in biology and an understanding of the complexity and urgency of the problems of agricultural and economic zoology in the tropics. While in India, Imms produced his best research work, among his papers at this time being a fine study of the morphology and biology of *Archotermopsis*, a primitive member of that most fascinating group of insects, the termites, the stupendous colonies and elaborate social organisation and caste system of which have been the marvel of zoologists since the end of the eighteenth century when entomologists first began to explore systematically the faunal riches of the tropics.

But it was not as an original investigator that Imms was to make his real mark. In 1913 he returned to England as reader in agricultural entomology in the University of Manchester, and he there commenced work on the great "General Text-book" already referred to. This was held up by the First World War and was not finished until 1925, by which time its author was chief entomologist at the Rothamsted Experimental Station. The text-book, a monumental work, has gone through many editions; it is in every way comparable with and in many respects superior to its famous predecessors, Packard's "Text-book of Entomology" (1898), Henneguy's "Les Insectes" (1904) and Berlese's "Gli Insetti" (1909). In this book Imms found full scope for his particular combination of qualities: an encyclopædic knowledge of his subject, a meticulous accuracy, a sound morphological insight and a well-balanced critical faculty. Indeed, it is the critical acumen and the balance of the book which are perhaps its most outstanding features, although the balance was somewhat upset in later editions by the immense growth of physiological investigation, a field in which Imms was less especially interested and which he left to others to summarize in text-book form. Imms was also the author of other valuable books, notably "Recent Advances in Entomology" (first edition 1930) and "Insect Natural History" (1947), and he produced the excellent articles on entomology in the "Encyclopædia Britannica".

Imms was elected a fellow of the Royal Society in 1929, and in 1931 he went to the Department of Zoology at Cambridge as first incumbent of the newly created readership in entomology. Here he built up a new sub-department and, during his time as reader, served on the Council of the Royal Society. He was president of the Royal Entomological Society of London and of the Association of Economic Biologists. When the main burden of text-book writing and the work of organising the sub-department was ended, Imms returned once more to personal research, and produced some valuable memoirs bearing particularly on morphological problems fundamental to questions of the ancestry of insects and phylogenetic relationships of the main orders. These included work on the growth processes in insect antennæ, on the constitution of the maxillæ and labium in the Mecoptera and Diptera—a study which throws a great deal of light on the relationships of the latter order—and an admirable short paper on the biology and relationships of that most puzzling insect *Braula cæca*, the 'bee louse'.

Personally Imms was reserved, and probably few people knew him intimately. Although he stimulated an immense quantity of valuable research through his writings, he was sometimes apt to appear discouraging to undergraduates, seeming on occasion to dishearten and chill by an apparent lack of enthusiasm. But in reality he was an excellent judge of promise in young research workers; he knew the real investigator directly he saw him, and he recognized and appreciated the type which would respond to criticism in the right way and whose ardour nothing would damp. A student of this quality could count on him for unswerving support and friendship.

Imms was elected a Fellow of Downing College in 1940, and his work for the College and his relations with its society constituted perhaps one of the happiest episodes of his career. When the Second World War came and the younger Fellows of the College left for war service, he unhesitatingly undertook the arduous duties of bursar and steward, thus entering on work with which he was previously altogether unfamiliar. Nevertheless, he made a real success of it and impressed all his colleagues with the rapidity and efficiency with which he got things done; he was particularly clever in making the most of the scanty time at his disposal, and it was astonishing how he contrived to carry this heavy burden of College work without apparently decreasing the time available for his scientific activities and without ever becoming in the least 'ruffled' over the sometimes irksome jobs which arose in the course of his duties. On his retirement from the University readership in 1945, Imms received the honour of election to an honorary fellowship at Downing. He was also honorary member of a number of learned societies in foreign countries, including France, Holland and Finland. The climate of Cambridge never suited Imms, and on retirement he therefore settled in Devon in the hope that he would enjoy better health

there. He soon began to take an active part in local affairs and to enjoy his garden and the new duties and obligations which life in a small rural community involved. But further illness soon supervened, and his last years were, in the main, a brave struggle against persistent and painful ill-health, in spite of which he managed to accomplish much valuable work in the way of revising and preparing new editions of his books.

Imms married in 1913 Miss Georgina Mary French, of County Tyrone, who, with their two daughters, survives him.

W. H. THORPE

Mr. W. A. Knight

MR. WILLIAM A. KNIGHT, the first headmaster of Sexey's School, Bruton, who died on April 11 at the age of eighty-two, was known as a leading educationist. From 1903 for some years he was a member of the Somerset Education Committee; during 1920–25 he served on the first Burnham Committee; in 1924 he became president of the Incorporated Association of Headmasters; and in 1928 he was elected to represent the English secondary school headmasters at the Bucharest Conference. He was an honorary M.A. of the University of Bristol, honorary associate of University College, Reading, and a J.P. for Somerset.

The opening of Sexey's School in March 1891 was due indirectly to an Elizabethan, Hugh Sexey (or Saxey), the founder of Sexey's Hospital, Bruton, certain accumulated funds of this institution being appropriated for the purpose. The Right Hon. Henry Hobhouse was chairman of the school governors until 1930. Mr. W. A. Knight, a native of Castle Cary, was only twenty-four at the time of his appointment, and during the thirty-six years until his retirement in 1927 he developed a school with highly distinctive traits. Bearing in mind a fundamental idea of the promoters to impart a strong practical and scientific bias to the curriculum, the youthful headmaster became a pioneer in the development of science teaching in schools. General elementary science, natural history, chemistry, physics and botany all found a place in the curriculum. A generation or so later, the importance of biological science in schools received general recognition. Up to the present time numerous Old Sexeians (many of whom are now well known in science) have taken a leading part in organising and developing biological work in schools, universities and research stations, both at home and overseas.

Gradually, under Mr. Knight's guiding hand, the school became known in the provincial universities, at the Universities of Oxford and Cambridge, and in Continental universities: so quick in its own soil was this acorn from a native Elizabethan oak. The record of Sexey's School shows that a proper emphasis on science in school teaching need not exalt material values at the expense of the spiritual. It is likewise remarkable that so many of Mr. Knight's pupils have developed strong literary and artistic tastes. The diverse fields in which alumni of this school have achieved distinction include the Church, literature, public affairs and administration.

In this little school, with her native human material and "Somerset's green lanes around her", the gifted headmaster was able to find full scope for his remarkable ability as a teacher, his organising genius and his inspiring ideals of attainment and character. Under Mr. Knight's tutelage one learnt as much out of school as within its walls. How, for example, could one remain indifferent to local history and topography when botany rambles with him led to such fascinating haunts as Wyke Champflower, Kingsettle Hill, Stourton Tower, Godminster and Holywater Copse?

The perennial charm and stimulating force of Mr. Knight's personality had much to do with the success of Sexey's School. He took a vivid interest in his pupils and their doings, both at school and afterwards. His memory of anything concerning them was amazing. In an unsurpassed measure he earned and kept the esteem and strong affection of his pupils, to whom he was always a personal friend as much as the ideal headmaster. In the words of a versatile old pupil (R. W. Gregory), who achieved eminence as an electrical engineer:

> You made us men, we boys of your own breed;
> And like the glowing steel, our mother wit
> With cunning hand you hammered into shape,
> And tempered for keen service to our kind.
> You made our School; a thousand boys and more
> You showed the way of life; and thorough men,
> Through all the continents of mother earth,
> Hold you in honour.

JOHN READ

PRESENT-DAY educationists, if they had had the opportunity, would have studied with interest, and acclaimed many points in, the pedagogical approach and the school organisation of Mr. Knight; for in many ways it was unique. For example, he would never allow 'holiday tasks', 'lines' or being kept in school after hours as a means of punishment. Both monitors (as they were then called) and staff could punish by a system of exclusions—exclusion for a definite period (which varied with the crime) from the gymnasium, the museum, the reading room, the fives courts, and even from the class-room (out of school hours). So boys never ran the risk of their literary appreciation being undermined through having to write under duress interminable quotations from authors; they always enjoyed complete freedom during their holidays: but the 'exclusions' proved to be so inconvenient that any sensible culprit thought twice before repeating his offence.

The school year was also divided into four terms, so that half-term rests were not necessary, and fatigue was reduced.

Mr. Knight also seemed to have a genius for choosing his staff to the best advantage. He was not easily bemused by high academic honours; capacity for work and the full recognition of the value of *esprit de corps* played important parts when he made a choice. Mr. Knight himself recently told me that, other things being equal, he would not mind whether his assistant was a 'pass' or an 'honours' man. One of his assistants recently coined the expression "the Sexeian habit"—the habit for hard work.

As Prof. Read writes, his "memory of anything concerning [us] was amazing"; and whenever we met him afterwards (no matter how many years had elapsed between), he was the headmaster, we the boys. In 1947, when the school honoured me by inviting me to present the prizes on Speech Day (well-nigh a quarter of a century after I had left the school), he took my hand and, without so much as a 'how d'you do', said: "But you have changed; you were always so very thin".

He was a great headmaster to whom science owes a considerable debt. He had no time for 'frills'; he got on with the job. The present headmaster, Mr. W. E. Page, writing to me recently, said: "We buried him, as he wished, with a minimum of ceremony and in the presence of scarcely a dozen people. It was moving in its stark simplicity." L. J. F. BRIMBLE

Mr. J. Hornell

MR. JAMES HORNELL, who died at Hastings on February 24 at the age of eighty-three, was a pioneer. He was one of the first marine biologists and fishery naturalists to be employed as such, and his experience of the fisheries of warmer seas placed him in a unique position for many years. Educated in Scotland and at the University of Liverpool, his early experience was gained on a fisheries survey of the Channel Islands, where he met his wife. Shortly after this he left England, and in 1904 was appointed marine biologist to the Government of Ceylon and four years later in the same capacity to the Government of Madras. Here he began a connexion with tropical seas which occupied the greater part of his working life.

In those years his efforts were mainly directed to the practical application of his investigations, and his elucidation of the cause of a decline in the Ceylon pearl oyster fishery, recommending action which brought back a substantial measure of prosperity, is an outstanding example of his achievements in this direction. Later, he made many other attempts at fishery development, among which may be mentioned his plea for the culture of fish in ponds and lagoons. In urging work of this sort, he produced a report on the conditions under which fish are farmed or cultured at Arcachon and Commachio, recommending similar action in India. The time for what we recognize as developmental and operational research was not yet, however, and the will and resources to implement his schemes were not forthcoming in a way that was worthy of his proposals. In addition to the pres entation of development schemes and the day-to-day distractions of administration which became his lot when he was promoted to director of fisheries in 1918, he managed to do a considerable amount of descriptive biology. It is, indeed, a matter for remark that, living so far away from the academic contacts that might have helped him, he dealt with these studies so competently. There is no doubt that, had he remained in England, his contribution to more fundamental fishery research would have been outstanding.

A rather special aspect of his scientific outlook arose from the application of a fisheries ecology which included men and gear in relation to the fish they pursued. This led him to produce interesting descriptions of fishing boats and gear before he retired from the Madras Government service in the early 'twenties, and which culminated in his classic "Water Transport, its Origins and Early Development", published only two years before his death. Aft he left India, he made many visits to British Colonial Dependencies and Mandated Territories, from which emerged a series of short fishery surveys of great value. In 1934 he went to live in Hastings, which remained his home for the rest of his life. Here he entered into the scientific life of the town, studying and describing the structure of local fishing boats and giving his welcome assistance to the Sussex Sea Fisheries Committee.

Hornell was gifted with a power of lucid exposition, evident in all his many publications, making them both a pleasure to read and models of style to those who come after him and regret his passing.

R. S. WIMPENNY

WE regret to announce the following deaths:

Sir Wyndham Dunstan, K.C.M.G., F.R.S., director during 1903–24 of the Imperial Institute, on April 20, aged eighty-seven.

Prof. F. S. Kipping, F.R.S., emeritus professor of chemistry in University College, Nottingham, on April 30, aged eighty-five.

Dr. W. J. Perry, lately reader in anthropology in the University of London, on April 29, aged sixty-one.

Sir Robert Robertson, K.B.E., F.R.S., formerly Government chemist, on April 28, aged eighty.

NEWS and VIEWS

Prof. Doris Mackinnon

PROF. DORIS L. MACKINNON, who retires from the chair of zoology at King's College, London, at the end of the present session, has held the post since 1927, when she succeeded Dr. Julian Huxley. She joined the staff of King's in 1919 when the late Prof. A. Dendy was head of the Department, and endeared herself to generations of students by her professional competence and her sympathetic, wise and helpful guidance. Prof. Mackinnon has published many noteworthy papers on her work, which deals almost entirely with parasitic Protozoa (especially flagellates and Sporozoa). During the First World War she joined the team of workers engaged in the diagnosis of amœbic dysentery and intestinal protozoal infections for the War Office and Medical Research Committee (now Council). When she went to London after the War, she soon established a centre of research in protozoology—for years the only zoological (that is, non-medical) centre of the kind in Britain. By her teaching and research and the work of her pupils, she has thereby done much to advance the subject; and her publications include many solid and permanent contributions to protozoology. As too frequently in academic appointments, the responsibility of administration tends to make inroads on time for research; but Prof. Mackinnon kept up a constant flow of publication and gave intercollegiate lectures of characteristic lucidity and thoroughness. In paying tribute to her gifts as a teacher, it would not be out of place to mention the admirable series of broadcast talks on natural history given to schools. Her services on the University and College Boards and Faculties were particularly appreciated, as she brought to them a breadth of outlook, sound judgment, scrupulous thoroughness and an altruistic approach not invariably observed on such bodies. Fortunately her retirement does not mean that she will cease her zoological work, and her colleagues and friends will still be able to enjoy her urbane and delightful companionship.

Silver Jubilee of the Indian Chemical Society

THE *Journal of the Indian Chemical Society* is now so well known that many will perhaps be surprised to learn that the Society is only twenty-five years old. The silver jubilee was celebrated at the annual meeting held in Allahabad on January 3 last, when messages of congratulations were received from sister societies in other countries, fittingly headed by one from the oldest Chemical Society, that of London, which recently celebrated its centenary. As was natural, many tributes were paid to the first president, the late Sir Prafulla Chandra Ray, to whom more than to anyone else must be given the credit for the development of chemical research in India. Some account of India's contributions to chemical science is given in a jubilee publication which contains photographs of the past presidents and honorary fellows. In the course of his address, the president, Prof. P. Ray, wisely laid particular emphasis on the importance of fundamental scientific research and to the lack of inspiring teachers and investigators in the schools and universities. According to Prof. Ray, the situation in this respect has recently become worse owing to the departure of many university teachers to take up administrative posts in Government departments. This is a danger present not only in India. Prior to delivering his address, the president announced the election of five honorary fellows, among whom we were glad to note the name of Sir Robert Robinson. We feel sure that, when the Society celebrates its golden jubilee, its fellows will look back with pride and thankfulness to those who served it during its first twenty-five years.

Men, Managers and Machines

IN his monograph "Scientific Management" (Monographs on Higher Management, No. 9, Department of Industrial Administration, Manchester Municipal College of Technology; May 1948), Mr. G. Chelioti urges that the essence of management is the art of getting things done through the agency of other human beings, and that management itself is incapable of becoming a science. He regards science as the foundation and the provider of the tools of industry, and the technician as the primary servant of science in industry; but he points out that the technician cannot manage human beings by means of his technology and that the manager dealing with a technical problem becomes a technologist for the time being. In urging this clear separation of the two functions of dealing with human beings and with technical problems or machines, Mr. Chelioti maintains that the undue domination of industry in the nineteenth century by the new element of modern technology, and the failure to regard industry as the servant of humanity and to consider sufficiently the human beings employed, was responsible for the revolt of the human spirit against subordination to the machine which we are still experiencing in spite of a more enlightened managerial outlook. Mr. Chelioti also reminds us that the current attitude of society was at least as much responsible for the revolt as the contemporary employers or managers, and his words should be carefully weighed in the discussion of the question of human relations in industry to-day.

Fungi as Human Pathogens

IT is fortunate that in Great Britain there are relatively few outbreaks of human disease caused by fungi. Such maladies are, however, much more common in the warmer parts of Europe and in the United States, where considerable study has been devoted to the diseases and their causal agents. Results of these investigations are published in the journal *Mycopathologia* (Dr. W. Junk, den Haag, Holland). The subject brings its own problems, particularly in naming and classification, some of which are discussed in a paper by T. Benedek (4, Fasc. 3; Dec. 1948). It is concluded that the dermatophytes cannot well be classified by the usual methods of botanical mycologists, and that it is preferable to retain the four form genera originally suggested by Sabouraud. This retains the tradition of the Fungi Imperfecti, where species are classified merely from the form of their asexual spores until the sexual forms are discovered. Mycologists will also find, in the same number of *Mycopathologia*, useful papers on the yeast flora of grapes, must and wine (R. Ciferri and O. Verona), and of the 'vegetation waters' separated from olive oil (R. Ciferri, O. Verona and F. Luparini). The blastomycetic microflora of fermenting tobacco is described by M. Giovannozzi. An investigation of antibiotic substances against Gram-negative micro-organisms has been made by G. Magni and A. Villa, and G. Magni has studied the biological significance of the pseudomycelium of asporogenous yeasts. W. J. Nickerson and O. F. Jillson also discuss the interaction of pathogenic fungi in culture, with reference to cell division in the dimorphism of pathogenic fungi. Specialist papers on mycopathology also appear; it is in no invidious sense that they are not reviewed here in detail. There are far more general mycologists than mycopathologists in Great Britain; but the former will nevertheless find much of interest in *Mycopathologia*.

Taxonomy of the Fungi

IN the issue for June 1948 of the *Transactions of the British Mycological Society* (31, Parts 3, 4) there are several papers which help to clarify the systemic positions of many fungi. A. A. Pearson and R. W. G. Dennis have reviewed the validity of the 1,870 specific epithets contained in the latest authoritative work on Agarics (Rea's "British Basidiomycetæ"). They have excluded synonyms, names attached to inadequate descriptions, and other variants of doubtful nomenclature, leaving a total of 1,234 species. Boletales have similarly been reduced from 70 to 47. The valid species are listed with short notes (pp. 145–190), and field mycologists should be grateful to the authors for the removal of such an incubus. This clarification has involved a re-examination by R. W. G. Dennis of several little-known agarics from the herbaria of Berkeley, Cooke and Massee; 29 of these are described in relation to the shorter list (pp. 191–209). Special groups of fungi have also been studied. The late T. Petch provides a revised list of British entomogenous fungi (pp. 286–304), including a new species, *Verticillium menisporoides*, found on spiders in Suffolk. Fungi which are associated with lichens have not hitherto been investigated very intensively. W. Watson lists (pp. 305–339) a large number of these, with notes on their characters and distribution. The Society's "List of Common British Plant Diseases" is kept up to date by the publication of emendations. A collection of these, designed to supplement the third edition of the List, appears in the present number of the *Transactions* (pp. 340–342). A new species of *Pyrenophora* from Italian ryegrass is described by

H. F. Dovaston (pp. 249–253). It is *P. Lolii*, and is possibly the perithecial form of *Helminthosporium siccans*. Other new species are described by N. C. Preston (pp. 271–276)—*Myrothecium jollymannii* from dried tobacco leaves in Nyasaland, and *M. striatisporum* from clay soil in New Zealand.

Establishment and Care of Lawns

Among the more general matters dealt with in a recent issue of the *Journal of the Board of Greenkeeping Research* (7, No. 24; 1948) are papers on the consolidation of lawn surfaces by bitumen, and a useful review of methods of earthworm control on lawns. R. B. Dawson and J. R. Escritt describe the method of stabilizing the surface of lawns by the application of sand and bitumen emulsion immediately after the grass seeds are sown. The treatment can also be applied to established turf. Lawn surfaces were much improved, and the process may be useful for small areas subject to heavy wear. Detrimental effects were not very marked, but the establishment of bent and timothy grasses was reduced. J. R. Escritt and J. H. Arthur review the methods available for earthworm control. Many species of earthworm do not form casts, and therefore are not a nuisance, but only help in aeration and soil mixing. Organic manures generally stimulate earthworm activity, while the presence of a turf 'mat' diminishes the production of unsightly casts. Factors of management and manuring are therefore important. The relative merits of mowrah meal, copper sulphate, potassium permanganate, derris, mercuric chloride, lead arsenate and other control substances are discussed and provide a very useful advisory review of this matter.

Sugar Beet Viruses

The virus of sugar beet yellows has not hitherto been regarded as seed-borne. Phyllis E. M. Clinch and J. B. Loughnane have shown, however (*Sc. Proc. Dub. Soc.*, **24**, No. 27; July 29, 1948), that seed of a new family of sugar beet (No. 41), when germinated, gives a considerable percentage of yellowed seedlings. The identity of this yellowing with sugar beet yellows is somewhat by implication; but the symptoms and physiological effects are similar. The paper also describes two types of yellows disease from commercial sugar beet crops in Eire. Sugar beet yellows is probably the most serious disease of this crop in England. R. Hull and Marion Watson have a useful paper in the *Journal of Agricultural Science* (**37**, Part 4, 301–310; 1948) on the relation of nutrition and variety with severity of yellows. Manurial treatments in general increase the yields of roots and sugar; but the losses caused by infection unfortunately increase proportionately as the mean yields increase. Fertilizers have little effect in varying the symptoms of the disease. Commercial varieties and some breeders' lines were tested for possible tolerance of the virus; but no useful indication of this was obtained.

Norwegian Strandflat

In a paper in the *Geographical Journal* of January on the "Geomorphology of Norway", Prof. K. M. Ström returns to the topic of the strandflat, a topic which has evoked much controversy in past years. He believes that marine abrasion is much in evidence, though corrie glacier abrasion has played its part. The low plain cuts across fjord deeps and corrie lake deeps, and though local glaciers have certainly played a notable part, it is in the main due to marine abrasion. Prof. Ström cites the example of Moskenesöy, which has practically no strandflat on the inner or sheltered side, but has an abrasion platform 8 km. broad on the exposed side. The tendency to stress glacial action in the formation of the strandflat is probably due to the study of the strandflat where it shows a hummocky appearance through an overflow by ice during the last glaciation. The main features of the strandflat seem to have been abraded at successively lower levels since early Miocene times up to late Pliocene; this has been followed by excavation by glaciers from the inland ice and corrie glacier erosion and, finally, post-glacial marine abrasion in the peripheral areas where changes of level due to isostatic recovery have been least.

Earthquakes during January

Fourteen strong earthquakes occurred in various parts of the world during January. The strongest were those on January 23, 24 and 27, with epicentres in the Indian Ocean (about 600 miles south-west of Sumatra), near the Tonga Islands, and in New Britain respectively. Three earthquakes had deeper foci than is normal; two, having a depth of about 100 km., occurred on January 23 and 24, and the third, depth 600 km., on January 13 with an epicentre south of the Fiji Islands. It may be noted that no earthquake is so far known to have had its focus at a greater depth than 700 km. All the earthquakes during the month occurred in well-known seismic areas, though the one on January 28 in the Atlantic Ocean some 1,100 miles east of Bermuda is not in an area from which earthquakes often occur. Observatory records have been received from the central stations of the United States Coast and Geodetic Survey and from Strasbourg, and from individual observatories at Beograd (Jugoslavia), De Bilt (Holland), Durham, Kew, Strasbourg, Stuttgart and Toledo (Spain).

Mekran (Baluchistan) Earthquake of November 28, 1945

C. G. Pendse has discussed all available data for the earthquake at Mekran in Baluchistan on November 28, 1945 (*Ind. Met. Dept., Sci. Not.*, 10, No. 125; 1948). The epicentre was in the sea off the Mekran coast, and strength 10 on the Rossi–Forel scale was attained in the epicentral area. The instrumental magnitude was about 6·7, and the energy was of the order of 10^{21} ergs. The earthquake was attended by a seismic sea-wave which affected the whole of the Arabian seaboard. At Karwar, about 1,000 miles from the epicentre, the wave flooded the creeks and inlets, and boats anchored in the harbour were cut off from their moorings. There was serious loss of life and property at Pasni, the height of the second wave there being estimated at between 40 and 50 ft. At Karachi four distinct waves were distinguishable, and at Bombay a seismic sea-wave 6½ ft. high was experienced. It has been reported that two rocky oval islets, about three miles apart, appeared about the same time as the earthquake, some 180 miles west-south-west of Karachi. One islet rose about 30 ft. above the water and the other about 100 ft., the former having an area of about 1½ square miles and the latter about a square mile. Earthquakes have occurred in the past in the area off the Mekran coast on February 4, 1938, and January 7, 1940. Earthquakes on land near the point occurred on September 2, 1938, October 29, 1941, July 3, 1942, July 4, 1942, and February 6, 1943. Very strong

earthquakes have occurred in the past at Chaman (Baluchistan) on December 20, 1892; at Kachhi (Baluchistan) on October 21, 1909; at Mach (Baluchistan) on August 27, 1931; as well as at Cutch on June 16, 1819, and at Quetta on May 31, 1935.

Southwest Research Institute, Texas

THE Southwest Research Institute, San Antonio, Texas, has approved of the establishment of a division of oceanography and meteorology and a division of petroleum technology in Houston, Texas. The division of oceanography and meteorology will be of particular scientific importance, since oceanographic data on the Gulf of Mexico are particularly scanty. The research in this field will commence with a survey of currents, the shifting topography of the shelf area, and marine life in the Corpus Christi area, and the work will then be extended eastwards. The schooner *Harpoon* has already been earmarked for research in the Gulf. The oceanographic work will be in two phases: first, the project of the Institute, which will be freely published; and second, the fulfilment of private contracts, which will be paid for by the firms concerned on a cost basis. The establishment of the division of petroleum technology in Houston is the result of the widespread activity with regard to petroleum in that area and the fact that the local industries have immediate problems which can well be undertaken by the Southwest Research Institute. The Institute itself is a non-profit, endowed research organisation.

Unesco Fellowship Handbook

THE secretariat of Unesco has prepared a most useful handbook providing details of all available opportunities for trans-national study and organised arrangements made in this field, which should be of real assistance to those wishing to travel out of their own countries for purposes of study. The handbook, which is intended to be the first of a series, constitutes a repository of information on the considerable investments by governments, universities, foundations and charitable institutions in the promotion of international study. Whether these fellowships or awards are designed to assist the reconstruction or development of a particular country, to encourage scientific research, to stimulate artistic exchange or to promote international understanding in general, they represent a striking volume of assistance from many sources to individuals chosen for their capacity to advance the course of learning and to profit from the cultural heritage of countries other than their own. Copies of the handbook, which may be obtained from H.M. Stationery Office, price 5*s*., show that more than ten thousand opportunities for international study are available for the year 1948–49.

Gamma-Emitting Materials for Industry

THE Ministry of Supply has recently announced that radium and radon can now be supplied for use in industrial radiography. Radium is available on hire only, and will remain the property of the Government. It can be hired for periods of not less than six months, and the average time to fulfil an order is two months. Radon is sold outright, and notice of one week is required for an order. Demonstrations of gamma-radiography for industrialists can be seen by appointment at the Ministry's Armament Research Establishment, Woolwich, London, and at the National Physical Laboratory, Teddington, Middlesex. Radium and radon are supplied by the Radiochemical Centre, Amersham, Bucks, and applications for purchase or loan should be addressed to that establishment.

Spectrographic Research Unit of the Medical Research Council

BY arrangement with the London Hospital, the Medical Research Council has established there a Spectrographic Research Unit under the direction of Dr. E. R. Holiday. The primary function of the Unit is to undertake original research work in the field of absorption spectrophotometry as applied to biological problems of medical interest; but advice and assistance will also be given to other branches of the Council's organisation using such methods. The Unit has been based on the spectrographic department originally established by the London Hospital, and during the last five years partly supported by the Council for the purposes which are now being developed.

Education of the Young Worker

A SECOND Conference on the Education of the Young Worker, with a special subject for consideration, "The Entry into Work, Guidance and Initiation", will be held at Manchester College, Oxford, during July 23–29, 1949. Like its predecessor in 1948, it has been arranged under the auspices of the University Department of Education, the director of which is Mr. M. L. Jacks, and aims at bringing together representatives from industry, education, central and local government departments, voluntary organisations and other bodies which are concerned in the education and welfare of young people between the ages of fifteen and twenty who are no longer in full-time education. The Conference will work in commissions; but whereas last year each commission had a special subject to consider, this year the subjects will be the same for all commissions, each of which will report its findings to the whole Conference at plenary sessions. Further information can be obtained from the Director, University Department of Education, 15 Norham Gardens, Oxford.

British Social Hygiene Council: Summer School in Austria

OWING to various difficulties connected with foreign travel, the Summer School on "The Family and the Nation", which the British Social Hygiene Council had arranged to hold at the University, Berne, Switzerland, during August 17–September 1, has now been transferred to Pertisau in the Austrian Tyrol. There will be no change in the lecture programme, which will deal with different aspects of family life, such as marriage problems, nutrition, human heredity, population, the welfare of old people, the problem family, and juvenile delinquency. As in the past, only the first week will be devoted to study, the second week being entirely free for rest and recreation and for excursions to places of beauty and interest in the surrounding countryside. The cost, including travel, hotel accommodation and tuition, will be approximately £34. Further information can be obtained from the Secretary, British Social Hygiene Council, Tavistock House North, Tavistock Square, London, W.C.1.

Royal Institution

At the anniversary meeting of the members of the Royal Institution held on May 2, the following officers were elected: *President:* Lord Brabazon of Tara; *Secretary:* Prof. A. O. Rankine; *Treasurer:* Dr. R. E. Slade; *Managers:* Prof. D. Brunt, Major W. H. Cadman, Sir John Craig, Mr. E. R. Davies, Dr. C. H. Desch, Prof. H. Dingle, Dr. P. Dunsheath, Prof. G. I. Finch, Prof. F. L. Hopwood, Dr. E. T. Paris, Prof. H. J. Plenderleith, Sir Harry Railing, Prof. H. R. Robinson, Prof. A. M. Tyndall, Mr. F. Wakeham; *Visitors:* Colonel S. J. M. Auld, Dr. H. E. Cox, Dr. H. J. T. Ellingham, Dr. R. E. Gibbs, Prof. H. Heywood, Mr. A. J. Hughes, Dr. L. H. Lampitt, Mr. R. Le Rossignol, Mr. A. Marshall, Dr. D. C. Martin, Dr. A. C. G. Menzies, Mr. J. W. Ryde, Mr. F. M. Saxelby, Dr. H. Shaw, Dr. O. H. Wansbrough-Jones.

Capper Pass Awards for Metallurgy

The Capper Pass Awards for 1948, which are recommended by a committee on behalf of the Institution of Mining and Metallurgy and of the Institute of Metals, have been won by the following: Messrs. C. Blazey, L. Broad, W. S. Gummer and D. P. Thompson (Metal Manufacturers, Ltd., Port Kembla, New South Wales, Australia) £50 jointly, for a paper on "The Flow of Metal in Tube Extrusion"; Mr. H. R. Potts (Minas de Rio Tinto) £50, for a paper on "Further Notes on Converter Practice at Rio Tinto"; Messrs. R. C. Trumbull (Pyrites Co., Inc.), W. Hardiek (Pyrites Co., Inc.) and E. G. Lawford (Rio Tinto Co., Ltd.) £50 jointly, for a paper on "Notes on the Treatment of Pyrites Cinders at the Plant of the Pyrites Co., Inc., Wilmington, Delaware". The money for these awards has been given by Messrs. Capper Pass and Son, Ltd., Bristol, and is allotted as follows: £100 each year for one or more awards to authors of papers on some aspect of non-ferrous extraction metallurgy submitted to the Institution of Mining and Metallurgy; and £100 each year for one or more awards to authors of papers submitted to the Institute of Metals and relating to some process or plant used in the fabrication of non-ferrous metals, contributed by persons engaged full-time in industrial practice. All papers relating to these fields and published in 1949 by either of the two Societies will be considered for awards; authors need not be members of either Society and may be resident in any country. Manuscripts should preferably be submitted in duplicate to either the Secretary, Institution of Mining and Metallurgy, Salisbury House, Finsbury Circus, London, E.C.2, or the Secretary, Institute of Metals, 4 Grosvenor Gardens, London, S.W.1, from whom further particulars may be obtained.

Royal Aeronautical Society: Awards

The Royal Aeronautical Society has announced the award of the following medals and prizes: *British Gold Medal*, for practical achievement in aeronautics, to Mr. S. Camm, director and chief designer, Hawker Aircraft, Ltd., for his outstanding work in the design and development of fighter aircraft; *British Silver Medal*, for practical achievement in aeronautics, to Lieut.-Commander E. M. Brown, for his outstanding achievements in advancing the technique of deck landing; *Royal Aeronautical Society's Bronze Medal* to Capt. R. N. Liptrot, for his work on helicopters; *Wakefield Gold Medal* to Mr. E. S. Calvert, for his work in the development of airport lighting; *George Taylor (of Australia) Gold Medal* to Mr. G. R. Edwards, chief designer, Vickers Armstrongs, Ltd., Weybridge Works, for his paper on "Problems in the Development of a New Aeroplane"; *Edward Busk Memorial Prize* to Mr. W. Stewart, for his paper on the "Flight Testing of Helicopters"; *Herbert Ackroyd Stuart Memorial Prize* to Mr. W. H. Lindsey, for his paper on "Development of the Armstrong Siddeley Mamba Engine"; *Usborne Prize* to Mr. D. R. Maguire, for his paper on "Enemy Jet History"; *R. P. Alston Memorial Prize* to Mr. B. A. G. Mcgowan, for his work in the flight testing of gliders; *Baden-Powell Memorial Prize* to Mr. R. J. Starling, for being the best entrant in the associate fellowship examination.

Announcements

Dr. John Ramsbottom, keeper of botany in the British Museum (Natural History), has been awarded a Grande Médaille Isidore Geoffroy Sainte-Hilaire by the Société d'Acclimatation et de Protection de la Nature.

The Institute of Metals has appointed the following to be honorary corresponding members for their respective countries: *Belgium*, Henri Féron, administrative director, Visseries et Tréfileries Réunis S.A., Haren; *Holland*, Max Hamburger, director, Royal Nederlandsche Lood- en Zinkpletterijen voorheen A.D. Hamburger, Utrecht; *Italy*, Dr. Leno Matteoli, vice-director, Istituto Scientifico Tecnico Ernesto Breda, Sesto S. Giovanni, Milan.

The Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1, has published as a booklet of sixty pages Appendix III from the "Universities Yearbook" of 1948. This Appendix consists of a list of postgraduate scholarships and grants for advanced study and research tenable at the universities of Great Britain and Ireland during 1948–49, and though the awards for 1949 have for the most part been already made, yet most of the information will be applicable to next year. The classification of contents is by subjects.

The Italian review *Ulisse* is offering a prize of one million lire (about £450) for the best work of popular science in the fields of physics or chemistry which has been published in the last five years. The prize is open to books published in Italian, French, English, Spanish and German, and three copies of each book entered for the prize should be sent to *Revista Ulisse* (Sezione Premio Europeo Cortina), Corso d'Italia 43, Rome, before June 15. If the winning work is by a non-Italian author, it is hoped to arrange for the book to be translated into Italian and published in Italy.

Reference was made in *Nature* of April 23, p. 618, to the setting up, by the Parliamentary and Scientific Committee, of a sub-committee to investigate the question of payment for scientific and medical teaching staffs at the universities. We are informed that in view of the new circumstances it has been decided not to proceed with this matter.

Erratum.—In the announcement in *Nature* of April 23, p. 634, relating to the Busk aeronautical studentship, it should have been indicated that, subject to the permission of the trustees, the student may carry out his research in Great Britain or abroad.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Radioactive Phosphorus in Biochemical Research

It is generally required in radioactive tracer procedure when applied to biochemical problems that the stable and radioactive molecules or ions possess identical configurations. Only when the two isotopic atoms are supplied in the same chemical form can it be assumed that living tissues will absorb them in the proportions applied. In experiments carried out here with phosphorus-32, it was found that this requirement was not satisfied, and since no information is available on the selectivity of the plants to isotopic elements in different chemical forms, our data cannot be interpreted.

A sample of radioactive disodium hydrogen phosphate with a phosphorus-32 activity of 0·1 millicurie, prepared by slow neutron bombardment of $Na_2HP^{31}O_4$ at the Atomic Energy Research Establishment, Harwell, was used. The irradiated salt was applied in aqueous solution to the roots of growing plants. At the end of the investigation, check experiments indicated that less than 50 per cent of the phosphorus-32 was present as orthophosphate. In other words, half the total phosphorus-32 was present in a different chemical form, or forms, from that of the main bulk of $Na_2HP^{31}O_4$. The analytical procedure used to establish the above fact was as follows: the orthophosphate was precipitated as magnesium ammonium phosphate, ignited to magnesium pyrophosphate, weighed to give 'total' phosphorus, and assayed for phosphorus-32 with a Geiger counter. This precipitate gave less than half the number of counts per minute given by the same volume of original radioactive solution evaporated to dryness in a counting dish. Only rigorous oxidation of the radioactive solution with concentrated nitric acid and 60 per cent perchloric acid prior to precipitation ensured the oxidation of all the phosphorus-32 to orthophosphate, and resulted in a pyrophosphate count comparable with that given by the evaporated aliquot.

Our attention was directed by the Atomic Energy Research Establishment to the work of Libby[1] in which effects of slow neutron bombardment on some inorganic compounds, including those of phosphorus, had been investigated. Libby confirmed that any molecule containing an atom absorbing a neutron would probably be decomposed by the initial recoil of the nucleus, resulting from the emission of the gamma quantum ($P^{31}_{15} + n^1_0 = P^{32} + \gamma$), in a general Szilard–Chalmers type of reaction[2]. In the case of orthophosphates, he suggested that this disruption would result in the ejection of oxygen, presumably the fragment containing the phosphorus-32 being in the form of a phosphite. By some process, however, which seemed to operate during irradiation, Libby found that in the final product about 50 per cent of the phosphorus-32 consisted of regenerated $Na_2HP^{32}O_4$ molecules.

In view of the increasing interest in the application of radioactive tracers to biochemical problems, it is desirable that prospective users of phosphorus-32 should be aware of the severe degradation of sodium orthophosphate which occurs during neutron irradiation in the atomic pile. If a material of a definite chemical form is required, it is essential to use phosphorus-32 prepared by pile irradiation of sulphur-32, and even then the identity of the active material should be confirmed before it is used.

W. D. E. Thomas
D. J. D. Nicholas

Research Station,
Long Ashton,
Bristol.
Nov. 26.

[1] *J. Amer. Chem. Soc.*, **62**, 1930 (1940).
[2] *Nature*, **134**, 462 (1934).

Effect of Enzyme Inhibitors on the Genesis of Phage

It is generally agreed that the multiplication of viruses is intimately linked with the metabolism of the host cell[1]. It seemed, therefore, interesting to study the influence of enzyme inhibitors on the development of virus within the host cell. In this connexion we have launched an extensive investigation with regard to the influence of enzyme inhibitors on the growth of the bacterial cell and the development of 'bacterial virus' particles respectively.

For our first experiments we have used a coli-phage system. Tryptose medium cultures of *Escherichia coli*, strain *B*, were infected with suspension of T_2 phage. The following procedure was adopted: after two and a half hours growth the *E. coli* culture was split up into equal parts, which were treated with various inhibitors for one hour. The number of lytic particles used was calculated so as to assure infection of each bacterium by no more than a single phage particle, and plating out was done after 20 minutes incubation. Some details of the method used have already been reported[2].

Some of the substances examined had no effect on host cell or phage (sodium malonate, sodium fluoride 1/5,000–1/10,000); a second group inhibited both elements in the experimental system (penicillin, acriflavine, mapharside, malonic acid in higher con-

Inhibitor	Concentration (m*M*.)	Number of lytic particles (percentage of original inoculum)
Control		2,000–10,000
Hydroquinone	30	58
	15	78
	7·5	84·1
	50	61·9
	5	86
4-6-Dimethoxy-toluquinone	5·5	99·3
	0·55	124
Tetramethyl-*p*-phenylene diamine	3	83·4
	0·3	85·3
Malonic acid	100	0·27
	20	94·8
	10	81·7
	10	63·2
	5	142
Iodoacetic acid	25	44·6
	5	62
	1	78·6
Auramine	0·66	108
	0·066	72·3
Sodium cyanide	50	11·4
	10	60·5
	5	84·4
Sodium fluoride	24	114
Calcium chloride	10	160
Urethane	300	77·4
Colchicine	0·008	115
	0·004	180
	0·0004	159

centrations); and a third group checked multiplication of phage, but had no obvious influence on the reproduction of *E. coli*, as was shown by controls (hydroquinone, 4-6-dimethoxy-toluquinone, tetramethyl-*p*-phenylene diamine, malonic acid, iodoacetic acid, auramine, sodium cyanide, sodium fluoride, calcium chloride, urethane, colchicine).

The influence of different concentrations of the substances belonging to this third group upon the multiplication of phage is summarized in the accompanying table.

The substances under consideration belong to different chemical groups, and their range of enzymatic inhibition is varied; but all seem to share one property, namely, that of interfering with succinic dehydrogenase. The influence of succinic dehydrogenase on the multiplication of viruses awaits explanation.

Suppression of the multiplication of phage is shown clearly by the figures in the table; but it seems to be merely temporary, since preliminary experiments with hydroquinone indicate the probability of phage increase at later stages.

J. W. Czekalowski
D. E. Dolby

Department of Bacteriology,
School of Medicine,
University of Leeds.
Nov. 4.

[1] Foster, C., Jones, J. H., Henle, W., and Dorfman, W., *J. Exp. Med.*, **79**, 221 (1944). Friedewald, W. F., *J. Exp. Med.*, **75**, 197 (1942). Parker, R. F., and Thompson, R. L., *J. Exp. Med.*, **75**, 567 (1942). Rasmussen, jun., A. F., Waisman, H. A., Elvehjem, C. A., and Clark, P. F., *J. Infect. Dis.*, **74**, 41 (1944). Sprunt, D. H., *J. Exp. Med.*, **75**, 297 (1942). Toomey, J. A., Frohring, W. O., and Takacs, W. S., *Yale J. Biol. Med.*, **15**, 477 (1944).

[2] Dolby, D. E., and Czekalowski, J. W., *Nature* [163, 608 (1949)].

Difference between Morphine and Synthetic Analgesics in their Actions on Ganglionic Transmission

The analgesic actions of certain new synthetic compounds, including pethidine and amidone, have been extensively compared with that of morphine[1]. It is assumed that this analgesic action is mainly due to a central effect, although the possible local anæsthetic properties of these compounds have not been investigated.

Pethidine and amidone, in common with morphine, inhibit both pseudo- and true cholinesterases[2]. There is no evidence to show that their anticholinesterase activity is related to their analgesic properties. But in view of the importance of acetylcholine in the mediation of impulses over autonomic pathways, it is of interest to determine how transmission through autonomic ganglia may be influenced by these drugs.

A structure in which such transmission can conveniently be examined is the cat's superior cervical ganglion perfused according to Kibjakow[3]. In our experiments, we studied the effects of morphine sulphate, pethidine hydrochloride, *l*- and *d-l*-amidone hydrochloride on normal and denervated ganglia, using the nictitating membrane as the indicator of transmitted nerve impulses.

None of these drugs when injected into the ganglion was able to excite a contraction of the muscle; but pethidine and amidone (*l*- and *d-l*-forms) depressed or abolished responses of the nictitating membrane to (1) electrical stimulation of the preganglionic nerve fibres, (2) injection of acetylcholine, and (3) injection of potassium chloride. The depressant effect of each drug was maximal ½–1 min. after injection; with small doses it wore off after 3–20 min.; while with larger doses it might be irreversible. In the case of pethidine, the effective dosage was 10–100 μgm., for *d-l*-amidone it was 5–50 μgm. and for *l*-amidone 1–10 μgm. Thus *l*-amidone was about twice as active as *d-l*-amidone and ten times as active as pethidine. Analogous results were obtained on denervated ganglia when acetylcholine or potassium chloride was used as stimulus.

The action of morphine is entirely dissimilar. In the normal ganglion, even doses so large as 2 mgm. do not alter the response to the above-mentioned stimuli; but in the denervated ganglion, doses of 100 μgm. and upwards have a very marked potentiating action for both acetylcholine and potassium chloride. In the increase of the size of contraction of the muscle, the effect was comparable to that obtained with eserine sulphate (2 μgm.), although it did not last so long.

In further experiments on anæsthetized cats, we have tested the effect of intravenous and intracarotid injections of *l*-amidone; we find that to depress the nictitating membrane response to preganglionic stimulation, the doses then required are 50–100 times greater than those used in the experiments on perfused ganglia. Since the addition of amidone to the general circulation does not diminish the nictitating membrane response to intravenous adrenaline, it seems probable that its depressant effect under both conditions of experiment is due to an action on ganglionic transmission.

In addition, tests carried out on the isolated frog rectus abdominis muscle have shown that its responses to acetylcholine are characteristically modified by pethidine, amidone and morphine: pethidine (minimal concentration 0·0001 *M*) and *l*-amidone (minimal concentration 0·00001 *M*) are depressant, whereas morphine (minimal concentration 0·001 *M*) produces a potentiation.

Concerning these observations, the following comments may be made.

(1) It would appear that the effect, if any, of the anticholinesterase activity on transmission in the autonomic nervous system of pethidine and amidone is overshadowed by their predominantly depressant action. In this connexion, it may be noted that pethidine (5–10 mgm./kgm. intravenously) decreases the irritability of the vagus nerve of the dog[4].

(2) In view of their depressant effects on synaptic transmission, an action which may not be confined to the autonomic nervous system, pethidine and amidone appear to be potentially more dangerous than morphine, which does not share this property.

(3) The quantitative differences between the activities of pethidine, *d-l*-amidone and *l*-amidone in depressing ganglionic transmission correspond approximately with the differences in their effectiveness as analgesic agents. In both cases pethidine is the least powerful, whereas *l*-amidone is the most powerful, and *d-l*-amidone is intermediate between the other two.

(4) The analogous behaviour of the frog rectus muscle and of the superior cervical ganglion in their susceptibility to the depressant effects of pethidine and amidone, and to the potentiating action of

morphine, is a further indication that the ganglion cell with its axon has many properties in common with the motor end-plate and its muscle fibre.

C. O. Hebb
H. Konzett

Department of Physiology,
University, Edinburgh.
Nov. 1.

[1] Schaumann, O., *Arch. exp. Path. Pharm.*, **196**, 109 (1940). Thorp, R. H., Walton, E., and Ofner, P., *Nature*, **160**, 605 (1947).
[2] Brindley, C. O., *Fed. Proc.*, **3**, 5 (1944). Greig, M. E., and Howell, R. S., *Proc. Soc. Exp. Biol. Med.*, **68**, 352 (1948)
[3] Kibjakow, A. W., *Pflügers Arch.*, **232**, 432 (1933).
[4] Gruber, Ch. M., Hart, E. Ross, and Gruber, Ch. M., *J. Pharmacol.*, **73** 319 (1941).

Sympathin

Many workers are now engaged in studies on the substance or substances liberated at the nerve endings when sympathetic nerve fibres are stimulated. In some cases, it has been shown to be adrenaline, whereas in others results indicate that it may be *nor*adrenaline. Recently, Bülbring and Burn[1] showed that even splanchnic nerve stimulation (after evisceration and ligation of the renal vessels in spinal cats) can result in the liberation of varying proportions of *lævo-nor*-adrenaline with the adrenaline.

In cats under chloralose and cocaine, after double vagotomy, we have been able to show that in at least two cases the nature of sympathin (as shown by effects produced in distant parts of the animal) depends upon the length of time the nerve has been sectioned before being stimulated. Stimulation of the hepatic nerve immediately after sectioning, for example, produced contraction of the denervated nictitating membrane, relaxation of the non-pregnant uterus and a rise of blood pressure, effects well equated by slow intraportal infusions of equi-pressor doses of adrenaline (not *nor*adrenaline). Two hours or more later, stimulation produced contraction of the nictitating membrane and a smaller rise of blood pressure but no action on the uterus, effects well equated by slow intraportal infusions of equi-pressor doses of *nor*adrenaline (not adrenaline). A very small stimulus to the splanchnic nerve applied immediately after, and several hours after, sectioning produced similar results, although the matching was carried out, in this case, by slow intravenous infusions of equi-pressor doses of adrenaline or *nor*-adrenaline. Hypogastric nerve stimulation did not, however, give corresponding results, for the sympathin effects as recorded by relaxation of the non-pregnant uterus were always equated by slow intra-arterial infusions of adrenaline.

After dibenamine (15 mgm./kgm.), stimulation of the hepatic nerve immediately following sectioning produced slight relaxation of the non-pregnant uterus, and a fall of blood pressure preceded by a small rise. The rise could be produced by sham stimulation and was probably due to constriction of the hepatic artery. The fall was well equated by slow intraportal infusions of adrenaline. Later, stimulation produced no effect on the uterus, and a rise of blood pressure only, corresponding to the action of slow intraportal infusions of *nor*adrenaline. Similar effects, however, could not be produced by normal adrenaline-reversal doses of ergotoxine.

It appears, therefore, that sectioning of some sympathetic nerves may be linked with the inhibition of methylation of the primary amine, so that stimulation produces more *nor*adrenaline and less adrenaline. In these cases, the normal adrenergic mediator may be a mixture of varying proportions of adrenaline and *nor*adrenaline.

It is hoped to analyse the blood at various stages and so identify the substance or substances liberated.

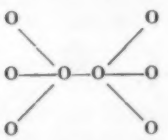
G. B. West

Pharmacology Department,
School of Pharmacy,
Bloomsbury Square,
London, W.C.1.
March 16.

[1] Bülbring, E., and Burn, J. H., *Nature*, **163**, 363 (1949).

Phloroglucitol Diammoniacate, $C_6H_6(OH)_6.2NH_3$

The determination of the crystal structure of phloroglucitol dihydrate, besides establishing the fact that the α-phloroglucitol molecule has the configuration x,x,x, shows that the water molecules are chiefly responsible for the cohesion of the organic molecules in the lattice[1]. The structure is rhombohedral, and in the (111) planes equilateral triangles of hydroxylic oxygens are formed, each of the three oxygen atoms belonging to a separate phloroglucitol molecule. On the line perpendicular to the plane of the triangles and joining the centres of two triangles, *two* water molecules are situated; and the distance from each water oxygen to the nearest three alcoholic oxygens and also the distance between the two water oxygen atoms is about 2·75 A. It is obvious, therefore, that the bonds linking together the



group are hydrogen bonds.

We thought it possible that a structure based on this arrangement might be preserved, at least at low temperatures, when the two water molecules are replaced by molecules of ammonia. Anhydrous phloroglucitol was therefore dissolved in liquid ammonia free from traces of water, and the ammonia allowed to evaporate slowly. The crystals formed in this way showed a development very similar to that of the dihydrate. They are quite stable when kept in a closed vessel at 0° C., but at room temperature and in the open air the ammonia escapes, leaving a powder of anhydrous α-phloroglucitol.

Taking special precautions it was possible, however, to obtain X-ray photographs of single crystals and to ascertain that the crystal structure corresponds to that of the dihydrate mentioned above. The lattice dimensions are, however, a little greater than those of the dihydrate. This is just what would be expected, because both the O—H—N and N—H—N bond distances must be somewhat larger than the corresponding O—H—O distances. The intensities of corresponding X-ray reflexions, although not identical, are very similar.

It seems reasonable to believe that the possibility of replacing water by ammonia is not limited to the hydrate of the trivalent alcohol in question, and it seems even possible that other substances than ammonia capable of forming hydrogen bonds may build up structures corresponding to those of the hydrates. Further studies in this direction, now in preparation, may give valuable information concerning the properties of hydrogen bonds. Full details concerning the structure of the phloroglucitol diammoniacate will be published in *Acta Chemica Scandinavica*.

Fig. 1. Part of the $C_6H_9(OH)_3.2NH_3$ structure projected along the trigonal axis

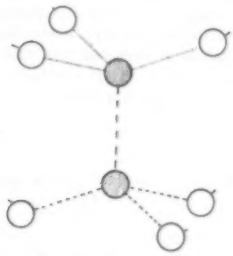


Fig. 2. The O_3—N—N—O_3 arrangement

In Fig. 1 part of the structure projected along the trigonal axis is reproduced; Fig. 2 shows the arrangement of the O_3—N—N—O_3 group.

PER ANDERSEN
O. HASSEL
Universitetets Kjemiske Institutt,
Blindern, Oslo.
Oct. 26.

[1] Andersen, Per, and Hassel, O., *Acta Chem. Scand.*, **2**, 527 (1948).

Structure of Polyglycine

IN a preliminary report on a chemical, X-ray and infra-red investigation of synthetic polypeptides[1], one of the forms of polyglycine was tentatively assigned a rectangular unit cell of dimensions: $a = 4{\cdot}36$ A. (or twice that), $b \approx 7$ A., and $c = 3{\cdot}44$ A. I should like now to correct this in the light of more recent considerations.

At a meeting in November 1948 of the X-Ray Analysis Group of the Institute of Physics, it was suggested by Bunn that polypeptides with shorter side-chains, and polyglycine in particular, might be expected to fit together in approximate close-packed arrangements like that found in the polyamides (nylons)[2], in which, though the interplane *spacing* is $4{\cdot}36_6$ A., the actual distance between chains bridged by CO . . . NH hydrogen bonds is 4·77 A. Rudall, working in this laboratory, and reviewing in another connexion the types of packing in protein structures, has also lately directed my attention to the improbably high density (about 1·8 gm./c.c.) that would be required if polyglycine had the rectangular cell proposed. We had no density data at the time; but the density of a preparation of polyglycine film has now been measured[3] and found to be close to 1·51 gm./c.c.

Taking Bunn's scheme and the same hydrogen-bonded distance between chains as in nylon, together with the residue-length (3·67 A.) estimated by Corey[4] for a completely extended polypeptide, the calculated density of polyglycine is

$$\frac{57 \times 1{\cdot}65}{4{\cdot}77 \times 3{\cdot}44 \times 3{\cdot}67} = 1{\cdot}56 \text{ gm./c.c.},$$

in satisfactory agreement with experiment. On this basis the β-angle is $\sin^{-1} 4{\cdot}36/4{\cdot}77 = 66°$; also, of course, practically the same as the corresponding angle in nylon.

The special importance of this result is in relation to the infra-red data[1], which show that in spite of substantial variations in backbone spacing, the CO . . . NH linkage remains virtually unchanged. Bunn's interpretation would be to keep a fairly constant inter-chain backbone distance (round about 4·77 A.) and let the β-angle increase with increasing side-chain distance until in β-keratin, for example, where the backbone spacing is 4·65 A., the cell becomes approximately rectangular (as direct observation shows[5]); and there seems little doubt now that this view is sound as regards polyglycine at least. Whether it is generally valid for polypeptides with longer side-chains—and there are evident difficulties at the moment—must await the results of calculations from density data not yet available.

W. T. ASTBURY
Department of Biomolecular Structure,
University of Leeds.
April 4.

[1] Astbury, W. T., Dalgliesh, C. E., Darmon, S. E., and Sutherland, G. B. B. M., *Nature*, **162**, 596 (1948).
[2] Bunn, C. W., and Garner, E. V., *Proc. Roy. Soc.*, A, **189**, 39 (1947).
[3] Dalgliesh, C. E. (private communication).
[4] Corey, R. B., *Chem. Rev.*, **26**, 227 (1940).
[5] Astbury, W. T., and Sisson, W. A., *Proc. Roy. Soc.*, A, **150**, 533 (1935); Astbury, W. T., and Dickinson, S., *Proc. Roy. Soc.*, B, **123**, 307 (1940).

Refining of Oils Containing Vitamin A

THE alkali-refining of fish liver oils containing vitamin A has, in the last few years, acquired increased importance due to the development of molecular distillation. This method of distilling, while yielding concentrates of a high vitamin A content, requires, in order to obtain satisfactory results, oils free from impurities and with low acid-values. Alkali-refining provides the best means of satisfying this requirement; but it has been considered that a treatment of this kind decreases the potency of vitaminic oils because of the adsorption of vitamin A by soaps formed *in situ*[1].

Experiments carried out in this Laboratory with a number of fish liver oils seem to indicate that under normal refining conditions just the opposite is the case. The neutralized oil, far from losing anything of its original potency, extracts to a large extent vitamin A from the soap formed during the neutralization, so that the result of the alkali-treatment is increased, and not diminished, potency. In oils with high potency and high acid-value, this increase can be quite substantial, as illustrated by the following example.

A sample of Groper liver oil with 120,000 I.U. of vitamin A per gm., 12·5 per cent free fatty acids and 3·95 per cent impurities[2] was neutralized with an excess of sodium carbonate, centrifuged and filtered. The results are shown below:

	Weight (gm.)	Vitamin A potency (I.U. per gm.)	Total content of vitamin A (I.U.)
Original oil	24·50	120,000	2,940,000
Neutralized oil	18·75	140,000	2,625,000
Oil in soapstock	5·75 (by difference)	44,000	253,000

The 5·75 gm. of soapstock oil consisted, according to the analysis, of 3·06 gm. fatty acids, 0·97 gm. impurities and 1·72 gm. neutral oil, which latter could be extracted with petrol ether from the soapstock. The potency of this oil can be assumed as 140,000 I.U. per gm., the same as the bulk of the neutralized oil, and consequently 1·72 gm. of it accounts for 240,800 I.U. out of the total of 253,000 I.U. in the soapstock. This leaves for the fatty acids in the form of soap, and for the impurities, 12,200 I.U., or less than 0·5 per cent of the total amount of vitamin A present in the original sample.

The loss of vitamin A during the alkali-refining is, therefore, due mainly to some neutral oil being carried away with the soapstock, while the potency of the neutralized oil has increased. As the latest refining methods allow of a loss closely approaching the theoretical Wesson loss, the amount of trapped neutral oil being reduced to a minimum, it seems now beyond doubt that alkali-refining provides the most economical and simple method of purifying oils containing vitamin A.

It may be added that the alkali-refining of vitaminic oils prior to molecular distillation is covered by a patent[3]. In the example contained in this patent, there is an indication of increased potency of neutralized oils, inasmuch as 4,600 gm. of pollack liver oil having a vitamin A potency of 10,600 units per gm. (or a total of 48,760,000 units) has yielded 4,285 gm. of refined oil with a vitamin A potency of 12,200 units per gm. (or a total of 52,277,000 units). This increase, however, shown without any explanation, amounts to a net gain of 3,517,000 units of vitamin A produced out of nothing, and, therefore, must be attributed to an experimental error.

L. HARTMAN

Fats Research Laboratory,
Department of Scientific and Industrial Research,
Sydney Street West,
Wellington, N.Z.
Nov. 5.

[1] Fish. Res. Board of Canada, Bull. No. 59, "The Chemistry and Technology of Marine Animal Oils" (ed. by H. N. Brocklesby), 259.

[2] Estimated by the method of Wesson and Jamieson. Jamieson, G. S., "Vegetable Fats and Oils", 454, 2nd edit.

[3] B.P. 526,289 granted to K. C. D. Hickman and Distillation Products, Inc.

Explosive Decomposition of Ethylene Oxide

THE slow decomposition of ethylene oxide vapour has received the attention of a number of investigators[1–3]. In extension of their work, we have studied the limiting conditions of temperature and pressure under which the reaction becomes explosive in a 550 c.c. quartz bulb.

At 773° K., the presence of nitrogen very slightly raises the minimum ignition pressure, as the following figures show:

Moles N_2 added per mole C_2H_4O	Pressure (partial) C_2H_4O at limit (mm.)
0	90
0·5	91
1·0	93

This result suggests that the ignition is of a thermal character and that, in accordance with the weight of opinion regarding the slow decomposition, the reactions leading to ignition do not involve chains. For such a thermal ignition the pressure (p) and temperature (T) at the ignition limit are related, theoretically, by $\log_{10} p/T = A/T + B$, where A and B are functions of the thermal properties of the system and the kinetics of the reaction leading to ignition.

We have traced the p–T explosion limit of ethylene oxide from 90 mm. at 773° K. to 325 mm. at 743° K., and find that between these points the graph of $\log p/T$ against $1/T$ indicates a continual decrease of A and/or B with rising temperature. The most probable explanation is that B is decreasing, thus implying an increase in the order of reaction with increasing temperature, that is, with decreasing pressure. This conclusion is in accordance with the findings of Thompson and Meissner[2] with regard to the slow decomposition reaction in the same pressure-range.

Our detailed conclusions on this subject, together with those relating to the flame reactions of ethylene oxide in the presence of oxygen[4], will be published in due course.

J. H. BURGOYNE
F. A. BURDEN

Department of Chemical Engineering
and Applied Chemistry,
Imperial College of Science and Technology,
London, S.W.7.
Oct. 25.

[1] Heckert, W. W., and Mack, E., *J. Amer. Chem. Soc.*, **51**, 2706 (1929).
[2] Thompson, H. W., and Meissner, M., *Trans. Farad. Soc.*, **32**, 1451 (1936).
[3] Seddon, R. V., and Travers, M. W., *Proc. Roy. Soc.*, A, **156**, 234 (1936).
[4] Cf. Burgoyne, J. H., and Burden, F. A., *Nature*, **162**, 181 (1948).

Stability of Chelate Complexes

ATTENTION has recently been directed to parallelisms in the order of the stability constants of the complexes formed by bivalent metal ions with different ligands[1,2]. We have investigated the stability constants of the complexes formed by metal ions with β,β′,β″-triaminotriethylamine, $N(CH_2CH_2NH_2)_3$, (tren), which can provide four ligand atoms for a given ion, as previously shown by Mann and Pope[3], who prepared complexes of this tetramine with several bivalent ions. The stability constants have been evaluated by combining the acidity constants of the acid $(trenH_4)^{4+}$ with the equilibrium constants of the reaction:

$$M^{2+} + (\text{tren}H_3)^{3+} = M(\text{tren})^{2+} + 3H^+.$$

Measurements were made at 20° C. with a hydrogen or glass electrode at an ionic strength of 0·1 (usually a 0·1 *M* solution of potassium chloride was used and a correction for chloro-complex formation applied where necessary). Except in the cases of silver and mercury, and to a much lesser extent nickel, intermediate steps do not occur in the neutralization of the acid in the presence of a complex-forming ion, the three protons being ejected together. This greatly simplifies the interpretation of the data. Furthermore, at the concentrations used (10^{-3} *M*) there was no indication of the formation of polynuclear complexes. The logarithms of the apparent stability constants

$$\left(k = \frac{[M(\text{tren})^{2+}]}{[M^{2+}] \cdot [\text{tren}]}\right)$$

are as follows (their dependence on ionic strength should be small since the ligand is a neutral molecule) :

M	Mn	Fe	Co	Ni	Cu	Zn	Cd	Hg
log*k*	5·8	8·6	12·3	14·6	18·8	14·6	12·3	~ 22·8

The order of the constants is in general the same as that observed with ammonia, ethylene diamine(en) and in other cases, in spite of the fact that a planar configuration is sterically impossible for the four nitrogen atoms surrounding the metal atom, which might be expected to lead to a decrease in the relative stability of the copper and nickel complexes.

	Mn	Fe	Co	Ni	Cu	Zn	Cd	Hg
$\log \frac{[M(\text{en})_3^{2+}]}{[M^{2+}] \cdot [\text{en}]^3}$	4·8*	7·5*	10·7*	14·1*	20·1†	11·1†	10·2†	—
$\log \frac{[M(\text{NH}_3)_4^{2+}]}{[M^{2+}] \cdot [\text{NH}_3]^4}$	—	—	5·3‡	7·8‡	12·6‡	9·1‡	6·9‡	~19·3

* Valid for 30° and ionic strength 1.
† Valid for 25° and ionic strength 1.
‡ Valid for 20° and ionic strength 0·1.

The loss of entropy on formation of a complex ion will be less when two or more ligand atoms are present in the same complex partner, but a comparison between the corresponding stability constants for ammonia, ethylenediamine[4] and β,β′,β″-triaminotriethylamine indicates that other factors, probably of a steric nature, are also of importance. It will be seen that the change in complex ion stability due to chelation varies considerably with the metal involved. The copper complex with β,β′,β″-triaminotriethylamine is actually less stable than that with ethylenediamine; an examination of the differences in the logarithms of the sets of stability constants given above indicates in the case of the ethylenediamine complexes a comparatively high stability of the copper and nickel complexes, and a low stability of the zinc and cadmium complexes. This is probably due to the tendency of copper and nickel to form complexes with a square configuration of the ligand atoms, whereas with zinc and cadmium the configuration is usually tetrahedral. In an ethylenediamine complex with a large central atom, the tetrahedral arrangement of amino groups will involve considerable strain in the two five-membered rings[5].

As in some other instances, the logarithms of the stability constants for β,β′,β″-triaminotriethylamine increase approximately linearly with the sum of the first two ionization potentials of the gaseous metal atoms, presumably indicating an underlying similarity between the electron energy-levels in the complex ions and in the corresponding metal atoms.

Details of our measurements with this and other 'complexons' will be published elsewhere.

H. Ackermann
J. E. Prue
G. Schwarzenbach

Chemical Institute,
University, Zurich.

[1] Irving, H., and Williams, R. J. P., *Nature*, **162**, 746 (1948).
[2] Calvin, M., and Melchior, N. C., *J. Amer. Chem. Soc.*, **70**, 3270 (1948).
[3] Mann, F. G., and Pope, W. J., *J. Chem. Soc.*, 482 (1926).
[4] Bjerrum, J., and co-workers, thesis, Copenhagen, 1941 ; *Kgl. Danske Videnskab. Selskab. Math. fys. Medd.*, **22**, Nr. 7, 3 (1945) ; *Acta Chem. Scand.*, **2**, 297 (1948).
[5] Mills, W. H., and Quibell, T. H. H., *J. Chem. Soc.*, 839 (1935).

Formation and Decomposition of Ferrous αα′-Dipyridyl

A recent note in this journal[1] on the reaction between ferrous ion and αα′-dipyridyl (Dipy) induces us to report briefly on our investigations of this reaction. In a general way, our experimental results confirm the findings of Baxendale and George; they reveal, however, some new aspects of this reaction.

The decomposition of $FeDipy_3^{2+}$ in acid (HCl) solution may be represented at $[H^+] < 5 \times 10^{-2}$ fairly well by the equation

$$-\frac{d}{dt}[FeDipy_3^{2+}] = \{k_{d_0} + k_{d_1}[H^+]\}[FeDipy_3^{2+}];$$

indicating that beyond the monomolecular decomposition of $FeDipy_3^{2+}$, there is a reaction involving hydrogen ions. As the value of k_{d_1} decreases sensibly at higher hydrogen ion concentrations, it may be supposed that the rate-determining step is the monomolecular decomposition of an intermediate, $FeDipy_3H^{3+}$, rather than a bimolecular reaction between $FeDipy_3^{2+}$ and H^+. On this assumption the kinetics may be represented correctly up to *p*H 0 by the equation

$$-\frac{d}{dt}[FeDipy_3^{2+}] = k_{d_0}[FeDipy_3^{2+}] + k_{d_2}[FeDipy_3H^{3+}] =$$

$$\left\{k_{d_0}\left(1 - \frac{[H^+]}{[H^+] + K_2}\right) + k_{d_2}\frac{[H^+]}{[H^+] + K_2}\right\}[FeDipy_3^{2+}]_{\text{total}}$$

The values of the constants at 25° and $\mu = 0{\cdot}33$ are $k_{d_0} = 7{\cdot}45 \times 10^{-3}$ min.$^{-1}$, $k_{d_2} = 8 \times 10^{-2}$ min.$^{-1}$ and the dissociation constant of $FeDipy_3H^{3+}$, $K_2 = 0{\cdot}6$. At $\mu = 0{\cdot}01$ the value of k_{d_0} decreases by about 10 per cent. The values of the activation energies are 29·5 kcal. for the reaction independent of hydrogen ion concentration and about 26 kcal. for that dependent on it, K_2 showing little or no dependence on temperature.

The formation of $FeDipy_3^{2+}$ from Fe^{2+} and $HDipy^+$ (αα′-dipyridyl HCl) at $[H^+] < 6 \times 10^{-2}$ follows approximately the equation

$$\frac{\Delta}{\Delta t_0}[FeDipy_3^{2+}] =$$

$$k_{f_0}[Fe^{2+}][Dipy]^3 + k_{f_1}[Fe^{2+}][Dipy]^3[HDipy^+] =$$

$$\left\{k_{f_0} + \frac{k_{f_1}}{K_a}[H^+]\right\}[Fe^{2+}][HDipy^+]^3\left(\frac{K_a}{K_a + [H^+]}\right)^3$$

(where $\Delta/\Delta t_0$ represents the initial velocity) if $[Fe^{3+}]$ is small in relation to $[HDipy^+]$. At higher concentrations of ferrous ions, an increase of these is not accompanied, however, by a proportional increase in velocity; on the contrary, after having reached a maximum value, the velocity decreases with a further increase of concentration of ferrous ions. Assuming that this behaviour is due to a rapid formation of an intermediate $FeDipy^{3+}$ which reduces the available concentrations of Fe^{3+} and $HDipy^+$ (and increases the concentration of hydrogen ions), it is possible to represent the kinetics within the experimental error of ± 10 per cent over a wide range of concentrations, especially with regard to the peculiar dependence on the concentration of ferrous ions, as shown in the table.

$[Fe^{2+}]$	1·37	5·5	55	165	555×10^{-5}
v_0 found	18·5	69	355	285	105×10^{-7} min.$^{-1}$
v_0 calcul.	18·7	68	331	310	107×10^{-7} min.$^{-1}$

$[HD^+] = 1{\cdot}66 \times 10^{-4}$, $[H^+] = 1{\cdot}60 \times 10^{-3}$, $T = 25°$, $\mu = 0{\cdot}33$

The values of the constants at 25° and $\mu = 0{\cdot}33$ are $k_{f0} = 2{\cdot}7 \times 10^{15}$ min.$^{-1}$ and $k_{f1} = 1{\cdot}75 \times 10^{12}$ min.$^{-1}$, using the values $K_a = 3{\cdot}7 \times 10^{-5}$ for the dissociation constant of $HDipy^+$ and $K_{FeDipy} = 2{\cdot}7 \times 10^4$ for the equilibrium constant of $FeDipy^{3+}$. At $\mu = 0{\cdot}01$ and $K_a = 4{\cdot}65 \times 10^{-5}$, K_{f0} is about $1{\cdot}7 \times 10^{15}$.

If $FeDipy_2^{3+}$ is assumed to be the sole stationary intermediate, it is not possible to represent the kinetics in a satisfactory manner. It is, however, possible to regard $FeDipy_2^{3+}$ as second intermediate, but only if its stationary concentration is small in comparison with the concentration of $FeDipy^{3+}$. This assumption is even probable on account of the form of the second term of the velocity equation.

The final, rate-determining steps would then be

$$FeDipy_2^{3+} + Dipy \rightarrow FeDipy_3^{3+}$$
$$\text{and } FeDipy_2^{3+} + HDipy^+ \rightarrow FeDipy_2H^{3+}.$$

The overall velocity constant is, within the experimental error, independent of the temperature, K_{FeDipy} showing a small negative temperature coefficient.

The equilibrium constant

$$K = \frac{[FeDipy_3^{3+}]}{[Fe^{3+}]\,[Dipy]^3} =$$

$$\frac{[FeDipy_3^{3+}]}{[Fe^{3+}]\,[HDipy^+]^3} \cdot \left(\frac{[H^+] + K_a}{K_a}\right)^3$$

is fairly constant only if $[Fe^{3+}] < [HDipy^+]$. With a correction, however, for the formation of $FeDipy^{3+}$, using the kinetic value of $K_{FeDipy} = 2\ 7 \times 10^4$, K remains constant over a very wide range of concentrations, even when the uncorrected value is so low as $K/100$.

The average value of the equilibrium constant at 25° and $\mu = 0{\cdot}33$ is $K = 3{\cdot}8 \times 10^{17}$, decreasing to about $2{\cdot}5 \times 10^{17}$ at $\mu = 0{\cdot}01$. The kinetic value of K calculated as the coefficient of the velocity constants of the opposed reactions is $3{\cdot}6 \times 10^{17}$, in excellent numerical agreement with the value directly found.

The heat of formation of $FeDipy_3^{3+}$ at 25° is about 28 kcal. Thus the velocity constant k_{f0} should have a small positive temperature coefficient (of less than 10 per cent per degree).

We shall try to find further confirmation of the existence of intermediates by investigating the kinetics in neutral solutions and by other methods. A full account of this work will be published elsewhere.

P. Krumholz

Research Laboratory of Orquima, S.A.,
São Paulo.
Jan. 6.

Baxendale, J. H., and George, P., *Nature*, **162**, 777 (1948); see also Kolthoff, I. M., Lee, T. S., and Leusing, D. L., *Anal. Chem.*, **20**, 985 (1948), on the analogous reaction with *o*-phenanthroline.

The value of K_{FeDipy} obtained by Dr. Krumholz from kinetic measurements agrees very well with a value of $1{\cdot}64 \times 10^4$ (independent of temperature) which we have obtained from equilibrium measurements based on the incomplete formation of $Fe(Dipy)_2^{3+}$ in excess ferrous ion reported earlier. It appears from our results that it is not possible to obtain appreciable amounts of $Fe(Dipy)_2^{3+}$; hence a precise value of K_{FeDipy_2} cannot be obtained, but only its upper limit, $K_{FeDipy_2} > 10^5$.

Over the *p*H range 0–2·5, our results on the dissociation of $Fe(Dipy)_2^{3+}$ in hydrochloric acid solution agree with those of Dr. Krumholz, although we believe that the simple explanation involving the formation of the intermediate $Fe(Dipy)_2H^{3+}$ is insufficient to explain the following observations. First, the first-order dissociation-rate constants at 35° C. depend on the acid used, and the differences cannot be accounted for by the differing hydrogen ion activities. Secondly, above 1·0 *N* hydrochloric acid, the rate constants are far below the predicted values based on $Fe(Dipy)_2H^{3+}$ formation. For example, at 25° and 35° C., the maximum first-order constants at high hydrogen ion concentration on this assumption (k_{Dipy_2}) are $8{\cdot}0 \times 10^{-3}$ and $33{\cdot}4 \times 10^{-3}$ min.$^{-1}$, whereas our observed values are $4{\cdot}4 \times 10^{-3}$ and $21{\cdot}6 \times 10^{-3}$ min.$^{-1}$ independent of the acid concentration. Experiments on dissociation in the presence of high salt concentrations at about 0·2 *N* acid show the rate constants to be little altered, so these effects cannot be attributed to kinetic salt effects.

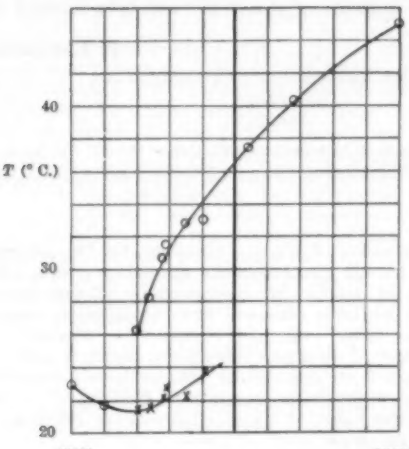
J. H. Baxendale
Philip George

Chemistry Department,
University, Leeds 2.

A Co-operative Transition in a Mixed Ketone Shown by a Change of Dielectric Constant

In a paper on the dielectric properties of dipolar solids, Fröhlich[1] considers the theory of second-order transitions in long-chain ketones. Starting from the crystal structure of these materials, he shows the possibility of co-operative transitions in the solid, and derives an expression for the behaviour of the dielectric constant at such a transition. This theory is derived for pure ketones; but so far no ketone has been found to show a transition of the type in question, the energy conditions being apparently unfavourable. However, such a transition has now been found in a binary mixture of a ketone and a paraffin, namely, 25 per cent of $C_5H_{11}COC_{11}H_{23}$ with 75 per cent of $C_{17}H_{36}$.

The mixture in question has two phases when in equilibrium, the main component being a solid solu-



o—o—, Stable melting points; ×—×—, metastable melting points

Fig. 1. Melting points of mixtures of $C_6H_{13}COC_{11}H_{23}$ and $C_{17}H_{36}$

tion of 10–20 per cent of ketone in paraffin, and the other predominantly the ketone. However, equilibrium is reached only after prolonged annealing, and the mixture can be quenched as a metastable homogeneous solid solution of ketone in paraffin. The physico-chemical properties of the mixture follow most clearly from the melting point diagram of the binary system $C_6H_{13}COC_{11}H_{23} + C_{17}H_{36}$ (see Fig. 1).

The dielectric constant of the mixture of 25 per cent ketone and 75 per cent paraffin was measured at two frequencies, 3×10^6 and 1×10^3 cycles/sec. A capacitor was used which allowed rapid quenching of the specimen. Fig. 2 shows a typical curve, obtained, in the case shown, on a quenched specimen at 3×10^6 cycles/sec. The results are independent of frequency, within the limits of error. It may be seen that within a considerable temperature interval below the melting point the dielectric constant behaves as in the liquid; the discontinuity at 22° C., the metastable melting point, appears to be due to volume changes and macroscopic orientation effects. The drop of the dielectric constant at about 4° C., which is independent of frequency, indicates a change of structure from one with mobile dipoles to one with immobile dipoles, the changes being gradual over a temperature interval. The values measured for the annealed, two-phase form are not materially different from those shown in Fig. 2 for the metastable form, since the main component of the mixture is still a solid solution of the ketone in paraffin.

The measurements in question are only preliminary. The necessity of quenching the specimen involved a reduction in the precision of measurement of both the dielectric constant and temperature. It is hoped to repeat them more exactly. However, they show clearly the existence of a co-operative transition analogous to that predicted by Fröhlich.

The existence of second-order transitions in paraffins is, of course, well known through the work of Müller[2], Ubbelohde[3] and others. The novelty of the present result consists in the fact that the transition found lies far below the melting point and that it can be followed by means of the dielectric constant, so that a theoretical treatment on the lines suggested by Fröhlich may be possible.

VERA DANIEL

British Electrical and Allied Industries Research Association, 5 Wadsworth Road, Greenford, Middlesex.

Nov. 8.

[1] Fröhlich, H., *Proc. Roy. Soc.*, A, **185**, 399 (1946).
[2] Müller, A., *Proc. Roy. Soc.*, A, **138**, 514 (1932).
[3] Ubbelohde, A. R., *Trans. Farad. Soc.*, **34**, 292 (1938).

Water Layers in Vermiculite

GRUNER[1] has shown that vermiculite consists of talc-like layers, 9·26 A. high, alternating with water layers (4·95 A.), the total water content of the mineral being in the region of 20 per cent. Theories[2,3] as to the nature of the water layers have found difficulty in explaining the observation[1,2,3] that, when vermiculite is heated at 110° C., about half the water is removed without apparently affecting the diffraction pattern. It can be shown, however, that a change in the structure does, in fact, take place during this treatment; but that the rapid rehydration which occurs on contact with normal atmospheric conditions tends to obscure it. Thus, while the diffraction patterns of unheated and rehydrated samples are identical, a powder specimen heated at 110° C. and sealed in a thin glass tube before rehydration can occur does not give the usual 14·2 A. basal reflexion of vermiculite but one at 11·8 A. corresponding to a water-layer thickness of 2·54 A., which is about half the original value. A single flake similarly treated shows the 11·8 A. reflexion to be associated with a regular sequence of higher orders; that is to say, it represents a real spacing and is not a diffraction effect from intimately mixed layers of dif-

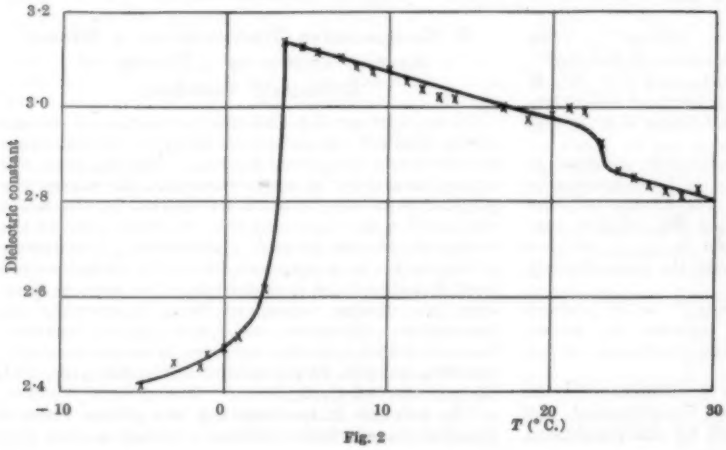


Fig. 2

ferent sizes[4]. It is clear, therefore, that removal of half the water is accompanied by replacement of an original double water-layer by a single layer.

The reason for the rapid and spontaneous rehydration which takes place on contact with atmospheric moisture is not so obvious, but appears to be bound up with the very high cation-exchange capacity of this mineral, which is comparable with that of montmorillonite. Tests made in this laboratory on several vermiculites have shown that the mineral has a maximum exchange capacity in the region of 130 m.equiv. per 100 gm., and that, in natural vermiculite, the exchange positions are always occupied by Mg^{2+} ions, the frequency of occurrence of these ions between the basal-plane surfaces being about 1·17 per unit cell.

In natural magnesium-saturated vermiculite, the height of a water layer is sufficient for each magnesium atom to be surrounded by a single hydration shell of six close-packed water molecules arranged octahedrally. Since the chemical formula[5] of vermiculite requires 16 water molecules per unit cell, there will be approximately 14 water molecules between the basic talc-like layers for each exchangeable magnesium ion and, for each octahedral group of magnesium-shell waters, approximately 8 'extra-shell' water molecules less tightly bound. According to the chemical formula of vermiculite, 30 per cent of the total water consists of hydroxyl groups, so that these 'extra-shell' water molecules would constitute almost half the total water content of the mineral, the half presumably which is released at 110° C.

The evidence suggests that, on removal of these 'extra-shell' molecules, the octahedral groups surrounding the exchangeable magnesium ions spread out over the basal-plane surfaces in a single layer; but that the strong tendency of the magnesium ions to become rehydrated causes reversion to the original structure as soon as extra moisture becomes available. Further, if the exchangeable magnesium ions occurring in natural vermiculite become hydrated in the manner suggested and their calculated frequency is of the right order, an inadequate amount of space would seem to be left for the development on any appreciable scale of Hendricks and Jefferson's[3] hexagonal groups of water molecules.

The theory outlined above requires that the configuration of the water layers in vermiculite should be largely determined by the type of exchangeable ion present, and this is, in fact, found to be so. Thus, replacement of the magnesium ions in exchange positions by monovalent and divalent ions causes changes in the c-dimension of the unit cell, as seen on an X-ray powder photograph; so that after leaching with a potassium salt, for example, the strong 14·2 A. basal reflexion of magnesium-saturated vermiculite is replaced by a diffuse line centred on 11·0 A., while ammonium-saturated material gives a broad line at about 10·6 A. and barium-saturated material a line at 12·3 A.

G. F. Walker

Macaulay Institute for Soil Research,
Aberdeen.
Nov. 10.

[1] Gruner, J. W., *Amer. Min.*, **19**, 557 (1934).
[2] Gruner, J. W., *Amer. Min.*, **24**, 428 (1939).
[3] Hendricks, S. B., and Jefferson, M. E., *Amer. Min.*, **23**, 863 (1938).
[4] Hendricks, S. B., and Teller, E., *J. Chem. Phys.*, **10**, 147 (1942).
[5] Hendricks, S. B., and Jefferson, M. E., *Amer. Min.*, **23**, 851 (1938).

Sublimation in Outdoor Air and Seeded Sublimation

At intervals over the past twelve months, expansion chamber tests of the threshold temperature for the formation of ice crystals in supersaturated air have been carried out at this College. Of the various weather conditions experienced, it was found that with strong sea winds (N. and S., 5 or more on the Beaufort scale), the threshold value remains constant at − 41·2° C., which is the value found previously for nuclei-free air[1]. In other weather conditions the threshold is variable between − 41·2° C. and − 32·2° C. The latter is the value already found for the ground layer of air in England. Diurnal variations are sometimes as large as 4° C. It appears that there is a whole 'spectrum' of sublimation nuclei in polluted air.

In view of the recent discovery of the seeding properties of silver iodide[2], its tendency to initiate the sublimation of water vapour was tested in an expansion chamber and on the test plates of hoar-frost hygrometers.

(*A*) *Expansion chamber tests.* Samples of chemically pure silver iodide were evaporated from a platinum wire, and expansion chambers were ventilated with air rich in silver iodide micro-crystals. The threshold sublimation temperature was found to be − 2·9° C. (± 0·1° C.). A decrease in the final temperature of a few tenths of a degree centigrade below this critical value practically fills the chambers with ice dust.

(*B*) *Frost point hygrometer tests.* Seeding of the surfaces of frost-point hygrometers with silver iodide micro-crystals was performed by condensing silver iodide (evaporated from a platinum wire) on polished surfaces. In testing various sizes of the crystals, it was found that the most active surface is one which is only just 'sensitized' by silver iodide (in the terminology of molecular beam physicists), that is, when the crystals are invisible. On such a surface, when freshly prepared, sublimation begins at − 2·9° C. (± 0·05° C.). At this critical temperature only a few ice crystals start to grow, and when air, supersaturated in respect to the dew point, was admitted over the surface, supercooled water started to deposit between the crystals, leaving clear areas closely around each crystal. With thimble temperatures above − 2·9° C., only supercooled water deposits on the thimble. When the thimble temperature is only 0·2° C. lower than the critical value, the sublimation activity of the surface is so high that it is impossible to deposit supercooled water even if very moist air is admitted to the hygrometer. The surface is covered at once with a multiplicity of ice crystals, resembling fine emery. The ageing of surfaces seeded with silver iodide proceeds relatively slowly. Twenty-four hours after evaporation of silver iodide and after many ice and water depositions on the surface, its sublimation threshold dropped to − 5° C. After a week of use the threshold value was − 10° C. With larger silver iodide crystals the critical temperature is somewhat lower, and with a quite coarse, clearly visible silver iodide deposit is − 5·5° C. The ageing process of coarser surfaces is similar to the 'sensitized' surfaces.

Though the seeding ability of silver iodide is not as high as that of zinc or cadmium, evaporated *in vacuo*[3], the surfaces seeded with silver iodide have the great practical advantage of being relatively last-

ing and very easy to reproduce. Sublimation on the surfaces seeded with silver iodide commences at temperatures somewhat lower than the frost point of the air under investigation, that is, between the frost point and the dew point, though generally closer to the former. Even with a seeded surface, therefore, the frost point should be determined by observation of the temperature at which ice crystals *present* on the surface are in equilibrium with the air under test, and *not* by determining the temperature at which ice crystals first appear on the surface[4]. In spite of this, the process of humidity measurements at temperatures between 0° and − 60° C. by the use of surfaces seeded with silver iodide is much simplified. Hitherto, such measurements have required a rather skilled observer owing to the difficulty of distinguishing between ice and supercooled water, either of which may be deposited on an unseeded surface in this temperature range. On the seeded thimble, this uncertain region is restricted to only a few degrees below freezing, when the error due to confusion between saturated vapour pressure of ice and water would be relatively small.

I wish to thank Mr. H. D. C. Waters, lecturer in chemistry at this College, for preparing samples of silver iodide from reagents of analytical purity.

B. M. Cwilong

Victoria University College,
Wellington,
New Zealand.
Aug. 4.

[1] *Proc. Roy. Soc.*, **A**, **190**, 137 (1947); *Nature*, **160**, 198 (1947); *Nature*, **161**, 62 (1948).
[2] *J. App. Phys.*, **18**, 593 (1947).
[3] *J. Glaciology*, **1**, 53 (1947).
[4] *Proc. Roy. Soc.*, **185**, 144 (1946); *Proc. Phys. Soc.*, **60**, 52 (1948).

Radar Observation of Heavy Rain

In view of the article on this subject which appeared in *Nature* of March 5, p. 372, it may be stated that the systematic exploration of clouds and rainfall by means of radar has been proceeding actively in Great Britain for some years past, though relatively little has been published, apart from official reports and memoranda. The photographs shown in the article referred to are characteristic of rainfall from a moving cold front.

Following upon successful experiments by the Telecommunications Research Establishment of the Ministry of Supply, a radar station at East Hill, near Dunstable, was taken over by the Meteorological Office for meteorological investigations. The station is equipped with A.M.E.S. Types 13 and 14 radar, operating on a wave-length of 10 cm. and using a pulse of 2-microsec. duration. The presentation on the display tube of the Type 13 gives range and height of the echo, while that of the Type 14 gives the bird's-eye view or PPI display. A simple switching device enables the Type 13 tube to be used to give the intensity of the echo, and in the cases under investigation the maximum intensity in the vertical column is usually examined particularly. Certain meteorological stations in the neighbourhood of East Hill are equipped for measuring rate of rainfall and drop-size, while the upper air data provided by the regular sequence of *radio sonde* ascents at the network in the British Isles are available to enable the phenomena to be related to the general meteorological situation.

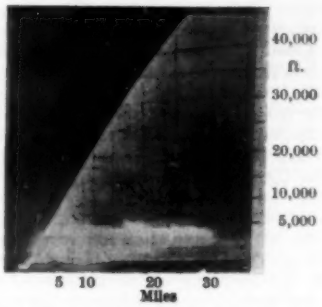


Fig. 1. January 29, 1948, at 1044 G.M.T.; bearing 246° T.

In addition, on selected occasions, the echo-producing clouds are simultaneously explored by an aircraft provided by the Royal Aircraft Establishment at Farnborough.

The object of the investigations is the study of the physical processes going on in clouds, including in particular the relation of the echoes to vertical currents and to icing which might constitute dangers to aircraft.

The results to date and earlier work which has been the subject of official reports cannot be described within the space available here; but two characteristic types of vertical sections are shown in the accompanying three photographs. Horizontal distance in miles is shown below the photographs and height in feet at the side.

Fig. 1, showing the 'bright band' effect, is found with layer-type clouds such as occur with weak and slow-moving or quasi-stationary fronts. Such bands are of limited vertical development, rarely giving responses down to ground-level and sometimes associated with a brighter band near the freezing-level. They are associated with relatively weak vertical air currents.

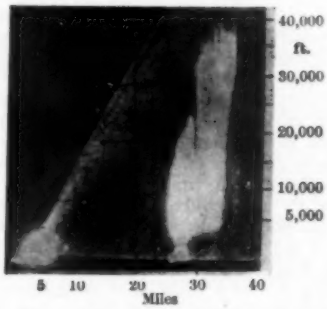


Fig. 2. July 30, 1948, at 1544 G.M.T.; bearing 194° T.

The outstanding feature of Fig. 2, on the other hand, is the appearance of strong vertical columns of echo, with clear-cut vertical edges and no indication of any 'bright band' phenomena. The more distant echo seen here comes from a thunderstorm extending to 40,000 ft., and the tendency to diverge near the top will be noted. The nearer echo was from a strongly developing new cumulo-nimbus. Such clouds have apparently liquid water drops at all heights, since they have been found to cause icing on the exploring aircraft.

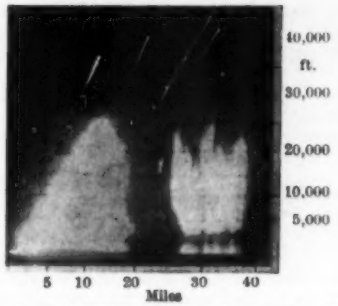


Fig. 3. June 10, 1948, at 0923 G.M.T.; bearing 176° T.

Fig. 3 relates to two extensive thunderstorms, one going on overhead and around the station, the other some 25–36 miles distant. The small isolated echo between at a height of about 17,000 ft. is from the observing aircraft, which is about to enter the second thunderstorm. In this case the accelerometer records from the aircraft appear to indicate that the peaks of the vertical columns were associated with strong upcurrents, the troughs with down-draughts.

This note is communicated by permission of the Director of the Meteorological Office.

R. F. Jones

Meteorological Office,
East Hill,
Nr. Dunstable.

Frictional Electrification of Dust and Pre-ignition in the Hydrogen Engine

The experiments on the frictional electrification of sand described by E. W. B. Gill[1] are of interest in respect of the pre-ignition and combustion knock generally observed when hydrogen is used as the fuel for an Otto-cycle internal combustion engine. Pre-ignition in the hydrogen engine is defined as ignition occurring during the induction stroke, that is, before the inlet valve closes.

Engine experiments by R. O. King, W. A. Wallace and B. Mahapatra[2] demonstrated that the effects mentioned were not obtained in the absence of carbon dust derived from pyrolysis of the lubricating oil even at a compression ratio of 10 : 1 and when using hydrogen–air mixtures in any ignitable proportion.

The engine experiments were resumed in September last, when the laboratory atmosphere was heavily impregnated with dust arising from the breaking up of part of the concrete floor. Pre-ignition was so severe that they could not be continued.

An air cleaner from an 85-h.p. motor-car engine was then fitted to the air intake of the C.F.R. experimental engine, which aspirates about 1/15 as much air. There was then no pre-ignition, and combustion knock was reduced sufficiently to permit completion of the experiments. The cleaner was of the type in which, on change of direction of the air stream, the particles of dust are thrown on to a sticky surface. In view of the oversize of the cleaner, it may be assumed that the larger particles only were removed from the air stream.

The engine experimental results, if interpreted in the light of those described by E. W. B. Gill, indicate that pre-ignition in the hydrogen engine when aspirating dust-laden air is due to discharges of electricity as between larger particles carrying negative charges and small ones carrying positive charges, remembering that potential differences would be increased by the friction between particles due to the air–hydrogen mixture passing the restriction of the inlet valve at high velocity. The air cleaner removes the large particles and pre-ignition is prevented accordingly.

R. O. King
W. A. Wallace
Edwin J. Durand

Department of Mechanical Engineering,
University of Toronto.
Nov. 12.

[1] *Nature*, **162**, 568 (1948).
[2] *Can. J. Research*, F, **26**, 264 (1948).

The 'Complex Indicatrix'

In discussing the application of Drude's 'complex indicatrix' for reflected light, M. Berek[1,2] originally extended the use of this term to include the two sheets representing the separate values for n and k. Thus he says, "The [cubic] complex indicatrix consists of concentric spheres with radii n and k". Strictly, the cubic complex indicatrix is, as he states elsewhere, a sphere with the complex radius $n\text{-}ik$, and is not itself geometrically representable. The n and k surfaces are representable for the more symmetrical crystals though not for the general case, and in some ways these surfaces take the place of the indicatrix of a transparent crystal. Nevertheless, this use of the term 'complex indicatrix' seems too wide, and I think this is Berek's opinion, for on looking through his later summary (1937)[3], I have not been able to find the term so used, though there is no direct reference to the question. No special designation is used for the curves there plotted (pp. 59, 60) and I have recently cited these under Berek's former nomenclature[4]. A term such as 'representative surfaces' for n, k, R, etc. would, however, appear to be more satisfactory.

As often happens, differences in notation have arisen in the accounts given by different workers. Berek consistently employs k for absorption coefficient, $\varkappa$ for absorption index ($k = n\varkappa$). In the English translation of Drude[5] (p. 360) $\varkappa$ is termed the coefficient of absorption, but later (p. 371) it is called the index. L. Capdecomme and J. Orcel[6] use χ in place of Berek's k and term it the "indice d'extinction". R. Galopin[7] uses k in place of Berek's $\varkappa$ and terms nk the "coefficient d'absorption". I understand that a further discussion from the mathematical side may be available in the new edition of the "Lehrbuch der Erzmikroskopie", Bd. I.[1].

A. F. Hallimond

Geological Survey and Museum,
Exhibition Road,
South Kensington,
London, S.W.7.
Oct. 26.

[1] Berek, M., in Schneiderhöhn, H., and Ramdohr, P., "Lehrbuch der Erzmikroskopie", 1 (Berlin, 1934), see p. 130.
[2] Rinne, F., and Berek, M., "Anleitung zu optischen Untersuchungen . . .", 16 (Leipzig, 1934).
[3] Berek, M., *Fort. Min. Krist. Petr.*, **22**, 1 (1937).
[4] Hallimond, A. F., "Manual of the Polarizing Microscope", 91 (York, 1938).
[5] Drude, P., "The Theory of Optics" (English trans. by C. Mann and R. Millikan, London, 1902).
[6] Capdecomme, L., and Orcel, J., *Rev. optique théor. et instr.*, **20**, 47 (1941).
[7] Galopin, R., *Bull. Suisse Min. Petr.*, **27**, 190 (1947) (see p. 197).

Root Nodules of Bog Myrtle or Sweet Gale (*Myrica Gale* L.)

Previous investigations[1] on the root nodules which commonly occur on *Myrica* spp. have referred chiefly to the structure and cytology of the nodules and to the identification of the endophyte. Little attention appears to have been paid to the possibility of fixation of nitrogen being associated with the nodules. Bottomley[2], after visual comparison of the growth made by plants (some with nodules, some without) transplanted from the natural habitat into a nitrogen-deficient soil, concluded that fixation of nitrogen had occurred. This finding deserves confirmation and amplification.

Satisfactory germination has been obtained with bog myrtle seed pre-treated by exposure in moist peat to a temperature of 2° C. for six weeks. Afterwards it was noted that this agreed with the experience of Barton[3] using seed of *M. carolinensis*. Seedlings were transplanted in May to water culture in Crone's solution (nitrogen-free formula, *p*H initially 5·0) and inoculated with a suspension of crushed nodules from field plants. Nodules appeared in three to four weeks. Seedlings not so inoculated did not develop nodules and showed very little growth, whereas all nodulated plants grew strongly (see photograph). Eight nodulated plants harvested after sixteen weeks growth in water culture showed a mean dry weight of 245 mgm. and a total nitrogen content of 7·3 mgm. per plant. Corresponding means for five non-nodulated plants were 6 mgm. and 0·1 mgm. respectively. These data strongly suggest that fixation of atmospheric nitrogen is associated with nodulated plants.

Young nodules developing under the above conditions show a red colour identical in hue with the pigmentation (presumably anthocyanin) which also appears in the hypocotyl of the seedling. A curious feature is that the roots which, in *Myrica* spp., develop from the tips of the nodules grow upwards (see photograph) and eventually project from the surface of the culture solution. The other roots display normal orientation. A parallel seems to be presented by the observations of McLuckie[4] on the tubercle roots of *Macrozamia*, which also exhibit upward growth.

Plants of bog myrtle (sweet gale) after twelve weeks growth in nitrogen-free water culture: left-hand plant with nodules, right-hand plant without nodules. × ¼

This investigation, to be continued, is associated with work on leguminous root nodules which is receiving support from the Agricultural Research Council.

G. Bond

Department of Botany,
University, Glasgow.
Nov. 12.

[1] Shibata, K., *Jahrb. f. wiss. Bot.*, **37**, 643 (1902). Youngken, H. W., *Amer. J. Pharm.*, **87**, 391 (1915). Shibata, K., and Tahara, M., *Bot. Mag. Tokyo*, **31**, 157 (1917). Schaede, R., *Planta*, **29**, 32 (1939).
[2] Bottomley, W. B., *Ann. Bot.*, **26** (1), 111 (1912).
[3] Barton, L. V., Contr. Boyce Thompson Inst., **4**, 19 (1932).
[4] McLuckie, J., *Proc. Linn. Soc. N.S.W.*, **47**, 319 (1922).

Preparing for the Occurrence of New Races of Rust

In Australia within the last eight years there have been two important cases of the breakdown of resistance to rust in wheat. The first was in 1942 when Eureka 2, a variety which, up to that time, had been highly resistant, suddenly became susceptible. This new stem rust has, on account of its close relationship with race 126, been designated as race 126*B* (unpublished data). The second case was in 1945, when Gabo was attacked by leaf rust (*P. triticina*) for the first time in Australia. This is also a rust unlike those previously present.

Eureka 2 and Gabo have proved particularly popular with growers, for under rust-free conditions in northern New South Wales, both are capable of high yields, they have a good straw and give a flour of satisfactory quality. The incorporation of leaf-rust resistance into Gabo is receiving immediate attention, and despite the big reduction in acreage sown to Eureka, we are endeavouring to add stem-rust resistance to it. These programmes will not be completed for some years yet and serious losses from rust may occur in the interim. Moreover, changes in the rust flora may render Gabo susceptible at any time.

It seems that when such satisfactory varieties have been bred, steps should be taken to prepare them for the possible occurrence of new races of rust. Although it is impossible to breed for resistance to specific races until they appear, we are working to a programme which it is hoped will give reasonable assurance of having, in a few years, a series of varieties equal to Gabo and Eureka 2 in yielding ability, and comprising certain ones resistant to new races of rust when they arise.

The problem of adding stem-rust resistance to Eureka 2 is a simple one, and already we have obtained from a back-cross of Gabo × Eureka 2 three resistant lines that seem the equal of the recurrent parent. However, it is considered unwise to concentrate solely on the one source of resistance, as there is no certainty that Gabo will continue to be resistant in the event of another rust culture greater in its parasitic capabilities than race 126*B*. To prepare for such an eventuality, we are using, in addition to Gabo, a diverse collection of varieties for crossing with Eureka 2. Varieties in this collection are known to have a fairly comprehensive stem-rust resistance under Australian conditions and include the following: Hofed, Fedweb, Celebration, Charter, *T. Timopheevi* × Steinwedel, Kenya 117*A*, wheat × rye, Khapli Emmer × Steinwedel and *Triticum* × *Agropyron*. These and others are being crossed individually

with Eureka 2, and in each case the resistant progeny will be back-crossed to Eureka 2 until sufficient of its genotype has been recovered. These recovered lines should all be morphologically similar, but during the course of the selection it may be possible to include a marker gene so that at a glance one can tell from which source the resistance has been added. At present, it is not known whether all the resistant varieties given above have different genes for rust resistance. In at least certain of them, the genes appear to be allelic. Despite the absence of this information the programme will not be affected, for should a new rust arise, then all those recovered lines that prove susceptible will be discarded. It is most unlikely that all resistant progenies obtained from such a diverse collection of parents will succumb at one time to the same rust. One or more of the surviving ones will, of course, be released for cultivation.

Preparing Gabo for the occurrence of a new strain of stem rust has not proved so simple, as this variety is already resistant to the Australian races. Continuous back-crossing to Gabo, using, say, Kenya 117*A* as the non-recurrent parent, would probably only recover the present Gabo resistance, unless there was available for test a specific race to which Gabo was susceptible. As such is not present here, and it seems unwise to introduce it, the programme is being carried out in two steps. The progeny of the Gabo × Eureka 2 cross mentioned above has been back-crossed twice to Gabo and selection has been for stem-rust susceptibility. After one more back-crossing, probably sufficient of the Gabo genotype will have been recovered. To this susceptible strain of Gabo will be added in turn the resistance of those varieties of the above collection. These recovered, resistant strains of Gabo, together with the resistant Gabo now being cultivated, should give some hope that even if a new race of rust does arise, one or more varieties will be immediately available capable of resisting it.

This programme is not being complicated by leaf-rust resistance at present, as this latter is a separate project. It is proposed to combine leaf- and stem-rust resistance as soon as practicable. A method closely resembling the one outlined for Gabo and Eureka 2 is being followed in breeding for rust resistance in linseed. Punjab is taken as the standard susceptible high-yielding variety. The resistance of several carefully selected parents is being added by the usual method of back-crossing.

I. A. Watson

Faculty of Agriculture,
University of Sydney.
Nov. 4.

Effect of Crude Benzene Hexachloride on Wheat Seedlings

There are numerous published references to the unfortunate effects of benzene hexachloride on the development of plants, both from seed[1–3] and from the tuber[4]. In only one of these reports, however, is any reference made to the question of the exact identity of the constituent of the crude material which is responsible for these effects[3]. Of the many isomers and impurities present in the crude material, only the gamma isomer is recognized as important as an insecticide. If the effects of benzene hexachloride on plants are due to some other constituent, the potentialities of the material as an agricultural insecticide may be greatly extended. To settle this question, experiments were begun in March 1948 by treating seed wheat with various preparations and constituents of benzene hexachloride, and observing the effects on germination and development.

The evidence indicates that plant deformation is not due to the gamma isomer. A mixture of trichlorobenzenes prepared by alkaline breakdown of alpha benzene hexachloride possesses this activity in far higher degree, relatively small doses causing the ultimate symptom, inhibition of germination. The material is active in the vapour phase. Possibly this active material is 1,3,5-trichlorobenzene, which has been shown to have this property[5], possibly another trichlorobenzene or some other volatile breakdown product of benzene hexachloride. Under natural conditions it is produced most rapidly by the breakdown of the gamma isomer, more slowly by the alpha isomer and at a quite unimportant rate, if at all, by the beta isomer. The material is effective in such low concentration that it may well have applications in the field of selective weed-killers. The exact nature of the material is still under investigation and detailed results will be published shortly.

Benzene hexachloride preparations for wheat-seed treatment against wireworms should be materials of high gamma content, applied at the minimum practical rate for control. The hazards accompanying their use are likely to be increased by storage after treatment, especially if ventilation is inadequate, by exposure to sunlight and by deficient moisture or high *p*H of the soil.

I am indebted to Dr. J. H. Whyte, of the Department of Botany, University of Alberta, for his help on botanical aspects of this work; also to Prof. D. L. Garmaise, of the Department of Chemistry, University of New Brunswick, and to Messrs. Canadian Industries, Ltd., who kindly provided many of the chemicals used.

B. Hocking

Department of Entomology,
University of Alberta,
Edmonton.
March 12.

[1] Kostoff, D., *Nature*, **162**, 845 (1948).
[2] McLeod, W. S., *J. Econ. Ent.*, **39**, 815 (1947).
[3] Stoker, R. I., *Ann. App. Biol.*, **35**, 110 (1948).
[4] Arnason, A. P., Fox, W. C., and Glen, R., *Can. Ent.*, **79**, 174 (1947).
[5] Gavaudan, P., and Gavaudan, N., *C.R. Soc. Biol.*, **133**, 348 (1940).

Persistence of Pyrethrins and Gamma Isomer of Benzene Hexachloride

In view of Beckley's advocacy of pyrethrum dust for weevil control in bagged grain[1], the following comparison with the gamma isomer of benzene hexachloride is of interest.

Laboratory tests were made against *Sitophilus granarius* using wheat dusted with 0·5 and 1·0 p.p.m. gamma benzene hexachloride from a commercial benzene hexachloride dust diluted with kaolin, and with 5, 10, 20 and 27 p.p.m. pyrethrins from powdered pyrethrum flowers. The treated grain was kept in open jars for 2–16 weeks at 28° C. and 70 per cent relative humidity before introducing the insects, and the jars were then closed. Mortality counts were taken at intervals up to 28 days. The tests were run in quadruplicate and the usual precautions observed.

Period of airing before infestation, weeks	2		10		16	
Count made.....days after infestation	10	28	10	28	10	28
Treatments and corresponding absolute mortalities, %						
Benzene hexachloride, gamma isomer, 1·0 p.p.m.	100	—	87	97	86	94
Benzene hexachloride, gamma isomer, 0·5 p.p.m.	95	97	43	61	10	17
Pyrethrins, 27 p.p.m.	76	81	28	38	3	1
Pyrethrins, 10 p.p.m.	8	12	9	8	—	0
Control, no dust	2	7	4	8	0	5

Results, detailed in the table, show not only that gamma benzene hexachloride at 0·5 p.p.m. is more toxic than 27 p.p.m. pyrethrins, but also that it is more persistent. The Agricultural Research Council finds that gamma benzene hexachloride at this dosage is free from health hazard.

H. H. S. Bovingdon

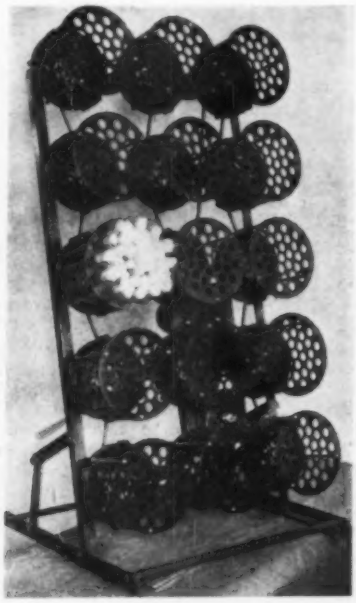
Imperial Chemical Industries, Ltd.,
Hawthorndale Laboratories,
Jealott's Hill Research Station,
Bracknell, Berks.

[1] Beckley, V. A., *Nature*, **162**, 737 (1948); *E. Afric. Agric. J.*, **14**, 71 (1948).

A Rotating Test-Tube Apparatus for Experimental Fermentations

The examination of different species or mutants of moulds calls for a simple and compact apparatus in which fermentations can be conducted in large numbers. The 'shaken flask' technique[1] has proved of great value, but even this requires a good deal of space if many tests are to be carried out at the same time.

To meet this special need a simple apparatus has been devised by which a large number of test-tube cultures can be satisfactorily aerated by rotation.



Each unit consists of a rack composed of two 6-in. diameter disks separated by supporting rods 3½ in. long. Both disks are drilled with 31 oversize ⅞-in. holes to carry test-tubes of that size. The units are mounted on ball races to reduce friction and are driven from a pulley by a suitable drive. A convenient apparatus consists of fifteen such units mounted on a steel frame, as shown in the photograph. Such an apparatus will fit into a laboratory incubator and will permit 465 fermentations to be made simultaneously. The degree of aeration can be changed by altering the inclination of the tubes through 16°.

From numerous trials we found that, with 5-ml. media in each tube, an angle of inclination of 11·5° and a speed of rotation of 100–120 r.p.m. gave satisfactory conditions for growing *Streptomyces griseus*.

The growths and titres obtained in this way were comparable with those obtained by other methods of carrying out small-scale fermentation.

I wish to thank Dr. A. J. P. Martin for his suggestions, and Mr. L. C. Maltby for making the apparatus.

P. B. Baker

Research Department,
Boots Pure Drug Co., Ltd.,
Biochemistry Division,
Nottingham.
Oct. 26.

[1] Elser, H. M., and McFarlane, W. D., *Can. J. Res.*, **26c**, 164 (1948). Kossler, H., Emerson, R. L., Perlman, D., and Burris, R. H., *J. Bact.*, **50**, 517 (1948). Prescott, S. C., and Dunn, C. G., "Industrial Microbiology", 378 (1940 edit.). Seustel, Irvin C., and Humfeld, H., *J. Bact.*, **52**, 229 (1946).

Another Little-known History of Botany

The recent review by Prof. F. E. Fritsch[1] of "A Forgotten History of Botany" by Karl F. W. Jessen has reminded me of another little-known book on the same subject, published in 1871 in Paris, under the signature of "L. G.". It is entitled "Précis de l'Histoire de la Botanique", and is one of the seventeen volumes of the botanical encyclopædia "Le Règne Végétal" published by a group of botanists of that period. The author of the "Précis" is perhaps the editor of the encyclopædia, L. Guérin, whose name appears at the bottom of the title-page; but this is merely a guess based on the initials which are used. The book seems to have been inspired mainly by Pritzel's first edition of "Thesaurus literaturæ botanicæ" (1851), but the "Précis" is stated to contain the titles of numerous publications unknown to Pritzel, especially French publications.

The book contains 535 pages, and some supplementary maps on plant geography. Its subject-matter is chronologically arranged and covers the whole field of history, beginning with "Before the Greek Civilization" (Chapter 1) to the nineteenth century (Chapter 7). There is an index comprising the names of all the authors cited in the book.

This history of botany is probably not as readable as Jessen's, since long lists of names are rather frequent, especially lists of titles of publications. However, I feel that the book is useful for purposes of reference, and I have often made use of it. If some person could give me precise information about its author, I should be grateful.

Jules Brunel

Botanical Institute,
University of Montreal.

[1] *Nature*, **163**, 115 (1949).

THE OIL-DROP METHOD FOR THE DETERMINATION OF THE ELECTRONIC CHARGE

By Dr. V. D. HOPPER
Physics Department, University of Melbourne

IT is generally accepted that the discrepancy between Millikan's[1] early value of the electronic charge, e ($4{\cdot}770 \times 10^{-10}$ E.S.U.), and the value derived by the X-ray method ($4{\cdot}8021 \times 10^{-10}$ E.S.U.[2]) can be accounted for by the uncertainty in the value of the viscosity of air at 23° C. (η_{23}). There exist, however, wide variations in the results obtained by different workers using the oil-drop method, even when the ratios $e^{2/3}/\eta_{23}$, which are independent of the absolute value of the viscosity, are compared. For example, the following values of $e^{2/3}/\eta_{23}$ have been derived from the results published by the authors: Millikan[1] $334{\cdot}96 \times 10^{-8}$; Bäcklin and Flemberg[3] $334{\cdot}12 \times 10^{-8}$; Ishida, Fukushima and Suetsugu[4] $336{\cdot}65 \times 10^{-8}$; Hopper and Laby[5] $335{\cdot}09 \times 10^{-8}$ (e E.S.U., η_{23} C.G.S.). In view of the large variation in these values, in spite of the internal consistencies of the separate experiments, it seemed desirable to make a systematic study of the oil-drop method itself, to find, if possible, the reasons for these differences and also an unexceptionable value of $e^{2/3}/\eta_{23}$.

In this study, the velocities of a drop were measured when acted on by the earth's gravitational field and by the combined action of the gravitational field and an almost vertical electrical field. The velocities were measured by photographing the drop with the aid of a spark which was triggered at intervals of 1/5 sec. The hole in the top plate of the condenser through which the oil drops entered the field of view was 0·368 mm. in diameter and displaced 2 mm. from the centre. Measurements of drop velocities were made in the centre of the condenser, a millimetre or so sideways from the hole, thus ensuring that the distortion produced by the hole on the electric field was negligible[6]. Care was taken to avoid an accumulation of oil on the lower plate of the condenser, as this also produces a field distortion. The condenser plates were slightly tilted in the direction of the optic axis of the camera, so that under the repeated action of the fields the drop was gradually brought into and finally out of focus. The plates were also tilted in a direction at right angles to the optic axis, so that the path of the drop took the form of a saw tooth across the field of view; and from a study of the photograph of the drop the position of best focus could be ascertained. It was also possible to repeat the process by displacing slightly the air in the apparatus, so that the drop was brought back to its original plane. The magnification of the camera was corrected for emulsion shift. Fig. 1 shows the path taken by an oil drop. The wavy sections of the path correspond to the small translation of the drop made to bring it back into focus.

In addition to the effect of the hole on the electric field between the plates, several other factors have been found to influence the experimental value of $e^{2/3}/\eta_{23}$ and are summarized here.

(1) *Purity of the air.* Measurements must be made soon after the admission of fresh air. With air which had been in the apparatus for several weeks, a value of $e^{2/3}/\eta_{23}$ was obtained which was consistently 0·3 per cent higher than that obtained with fresh air. This effect was attributed to impurities coming from the walls of the apparatus and contaminating the air.

(2) *Correction for the walls.* The correction to Stokes's equation due to the influence of the walls of the apparatus increases considerably the value of $e^{2/3}/\eta_{23}$ of some of the previous workers. An auxiliary experiment was carried out[7] which confirmed the Lorentz formula for the effect of a single wall on the motion of a falling oil drop.

(3) *Oxidation of the oil.* Results using Apiezon oil *B* and castor oil confirmed the conclusion of Ishida *et al.*[4] that oxidation or absorption occurs with oil in the form of very small drops. It was observed that using these oils the downward velocity of the drop when under the action of gravity increased gradually with time, whereas the upward velocity due to the combined action of the gravitational and electrical fields showed a decrease. Fortunately, the variations in these velocities tend to cancel each other in the determination of $e^{2/3}/\eta_{23}$, but a serious error might occur if a drop is studied for long periods after spraying. This effect could not be detected with butyl sebacate, and this oil was used for the determination. Fig. 2 shows the variation of velocities with time of two drops of Apiezon oil *B* (measurements for Fig. 2 *B* were taken from the drop photographed in Fig. 1), one drop of castor oil and one of butyl sebacate.

(4) *Impurities in the oil.* Erratic results occurred occasionally if the steel wire brush used for producing the oil drops was nearly dry. This was attributed to impurities in the oil. Some drops have been photographed which showed definite fluctuations in light intensity, due, it is believed, to small steel particles held in the drop. To reduce the possibility of impurities influencing the results, the brush was cleaned regularly and impregnated with fresh oil.

Fig. 1. Path of Apiezon *B* oil drop ($n = 22$ (electrons), $a = 3{\cdot}90\ \mu$) which had been refocused several times. The wavy sections correspond to the small translation of the drop made to bring it into focus

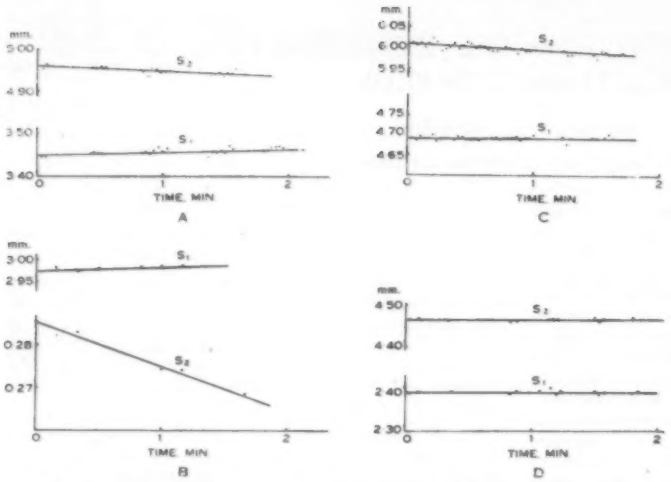


Fig. 2. Variation of drop velocity with time: (*A*) Apiezon oil *B*; (*B*) Apiezon oil *B*; (*C*) castor oil; (*D*) butyl sebacate. S_1 is proportional to the velocity of the drop when under the action of gravity; S_2 is proportional to the velocity of the drop when under the combined action of the gravitational and electric fields

Some of the above factors make marked changes in the values of $e^{2/3}/\eta_{22}$ previously quoted. The result of Bäcklin and Flemberg[2], namely, $334{\cdot}12 \times 10^{-8}$, which was the only one giving a value of $e^{2/3}/\eta_{22}$ agreeing with both the X-ray value of the electronic charge and Kellström's value ($1835{\cdot}0 \times 10^{-7}$ C.G.S.) for the viscosity of air at 23° C., is increased by the correction for the walls to $335{\cdot}03 \times 10^{-8}$. As no data were given regarding the size of the hole used in these experiments, the correction for this cannot be calculated; but it has been estimated that had a hole 0·6 mm. in diameter been used and measurements made below its centre, the above value of $e^{2/3}/\eta_{22}$ must be increased to $335{\cdot}9 \times 10^{-8}$. Following the criticism by Birge[3], the result of Hopper and Laby[4] has been recalculated. Using the same method of analysis for both the castor oil drops and the Apiezon oil *B* drops, the value of $e^{2/3}/\eta_{22} = 335{\cdot}13 \times 10^{-8}$ is obtained, whereas for the Apiezon oil *B* results alone the value is $335{\cdot}40 \times 10^{-8}$. The correction for the wall effect is uncertain, since in that experiment the plates were vertical, but it will increase these values by at least 3 parts in 1,000. (The actual correction may, however, be less than this as the purity of the air may be open to question.) Ishida *et al.*[4] were the only workers to make corrections for the change in density of the oil, and their value corrected for the effect of the walls becomes $336{\cdot}95 \times 10^{-8}$. A correction was necessary to this work owing to an error in voltage measurements[5]. From a recent private communication Prof. Ishida states that this correction, which was determined much later, was found to be as much as $-1{\cdot}1$ per cent. The experiment has been repeated by Ishida, Suetsugu and Matsui, giving, it is stated, $e = 4{\cdot}794 \times 10^{-10}$ E.S.U. ($\eta_{22} = 1{,}830 \times 10^{-7}$ C.G.S.), whence $e^{2/3}/\eta_{22} = 334{\cdot}72 \times 10^{-8}$. If the same correction for the walls is assumed for this as for the 1937 work, the value will be increased slightly to $335{\cdot}02 \times 10^{-8}$. Millikan's value will be increased slightly to $335{\cdot}10 \times 10^{-8}$ if the wall correction is applied. There is internal evidence in this work of a gradual variation in density of the oil, but a correction for this was not made.

In the present investigation, from measurements of forty-seven drops using voltages of 4,000 and 2,000, and for values of $1/pa$ ranging from 21·2 to 174·4, the value of $e^{2/3}/\eta_{22} = (335{\cdot}75 \pm 0{\cdot}11) \times 10^{-8}$ was obtained. Fifty-one values of $e_1^{2/3}/\eta_{22}$ (that is, values of $e^{2/3}/\eta_{22}$ uncorrected for the slip term[1]) from these forty-seven drops are plotted against $1/pa$ in Fig. 3. The value of $e^{2/3}/\eta_{22}$ corresponds to $1/pa = 0$ and will be increased slightly if Oseen's[6] modification to Stokes's analysis is applied, but the increase will be less than + 0·04 per cent.

A summary of the results of several careful determinations of the viscosity of air made since 1913 is given in the accompanying table. Derived values of η_{22} obtained from the corrected oil-drop values of $e^{2/3}/\eta_{22}$ (assuming $e = 4{\cdot}8024 \times 10^{-10}$ E.S.U.) are also tabulated. There is a wide variation between recently determined values of the viscosity, four of those tabulated being close to $1834{\cdot}2 \times 10^{-7}$ C.G.S. and the remaining two being close to $1829{\cdot}5 \times 10^{-7}$. The value adopted by Millikan for his 1917 work was $1822{\cdot}7 \times 10^{-7}$ C.G.S. The present investigation implies a value of $1826{\cdot}5 \times 10^{-7}$ C.G.S. if $e = 4{\cdot}8024 \times 10^{-10}$ E.S.U. is assumed for the electronic charge.

There is reason to believe that the electrical and mechanical measurements involved in the determination of the electronic charge by the falling drop method can be made with sufficient accuracy. The difficulties inherent in the measurement of the viscosity of air represent a greater limitation to the reliability of the method.

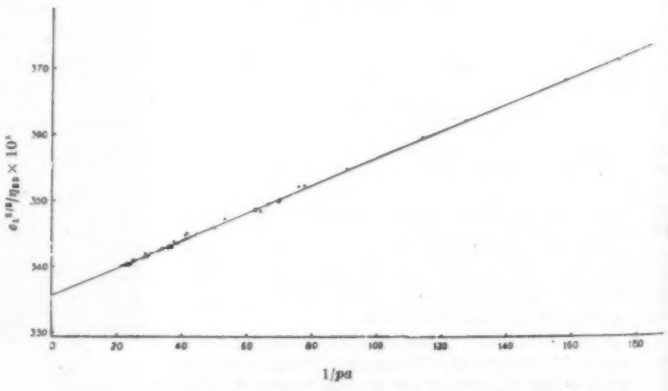


Fig. 3. Fifty-one values of $e_1^{2/3}/\eta_{22}$ (butyl sebacate drops) plotted against $1/pa$.

Viscosity of air at 23° C.

Author	Date	Method	Comments	$\eta_{23} \times 10^7$	Claimed uncertainty* $\times 10^7$	Reference
Gilchrist	1913	R.C.		1825·6	3·6	10
Rapp	1913	C.F.		1823·1	1·8	11
Markwell	1916	C.F.	Repeat of Rapp experiment	1827·3		12
Harrington	1916	R.C.	Same apparatus as Gilchrist	1822·6	1·8	13
Kellström	1937	R.C.		1835·0	3·0	2
Houston	1937	R.C.	Apparatus designed by Millikan and Day	1829·13	4·5	2
Bond	1937	C.F.		1834·34	0·8	2
Rigden	1938	C.F.	Completion of Bond's preliminary investigation	1829·96	0·7	2
Banerjea and Plattanaik	1938	C.F.		1833·75	2·2	2
Bearden	1939	R.C.		1833·79	0·06	2
				Derived values		
Millikan	1917	F.D.	No allowance made for slight density variation	1830·0	1·2	1
Bäcklin and Flemberg	1936	F.D.	Small apparatus. Correction for hole uncertain and likely to be important	<1830·4		3
Ishida, Fukushima and Suetsugu	1937	F.D.	Similar apparatus to Millikan. Corrected for density variation	1820·0	0·8	4
Hopper and Laby	1941	F.D.	Small apparatus. Vertical plates. Wall correction uncertain	<1824·6		5
Ishida, Fukushima and Suetsugu	(1948)		Voltage correction applied to their previous result (unpublished)	1833·6		
Ishida, Suetsugu and Matsui	(1948)	F.D.	New determination. Corrected for density variation (unpublished). (Uncorrected for density variation)	1830·4 (1829·2)		
Present investigation	(1948)	F.D.	Small apparatus. A decrease <0·04 per cent may be necessary owing to the Oseen correction	1826·5	0·6	

R.C. Rotating cylinder method.
C.F. Capillary flow method.
F.D. Falling drop method, assuming $e = 4{\cdot}8024 \times 10^{-10}$ E.S.U. (see ref. 14).
(Viscosities have been corrected for temperature using Sutherland's formula.)
* Inconsistent methods of estimation of errors used.

Miss A. Grant assisted in many of the measurements and in computing the results. I am also indebted to Prof. L. H. Martin for many helpful discussions during the course of this investigation, details of which will be published in the *Australian Journal of Scientific Research*.

[1] Millikan, R. A., *Phys. Rev.*, **34**, 1 (1917).
[2] Birge, R. T., *Amer. J. Phys.*, **13**, 63 (1945).
[3] Bäcklin, E., and Flemberg, H., *Nature*, **137**, 656 (1936).
[4] Ishida, Y., Fukushima, I., and Suetsugu, T., *Sci. Pap. I.P.C.R. (Japan)*, **32**, 57 (1937).
[5] Hopper, V. D., and Laby, T. H., *Proc. Roy. Soc.*, A, **178**, 243 (1941).
[6] Hopper, V. D., *Nature*, **158**, 786 (1946).
[7] Hopper, V. D., and Grant, Alison M., *Aust. J. Sci. Res.*, A, **1**, 28 (1948).
[8] Ishida, Y., *Sci. Pap. I.P.C.R. (Japan)*, **33**, 1785 (1937–38).
[9] Oseen, C. W., *Ark. Mat. Ast. Fys.*, **6**, No. 29 (1910).
[10] Gilchrist, L., *Phys. Rev.*, **1**, 124 (1913).
[11] Rapp, I. M., *Phys. Rev.*, **2**, 364 (1913).
[12] Markwell, E., *Phys. Rev.*, **8**, 479 (1916).
[13] Harrington, E. L., *Phys. Rev.*, **8**, 738 (1916).
[14] Du Mond, J. W. M., and Cohen, E. R., *Rev. Mod. Phys.*, **20**, 82 (1948).

ACTION OF SURAMIN ON ENZYMES

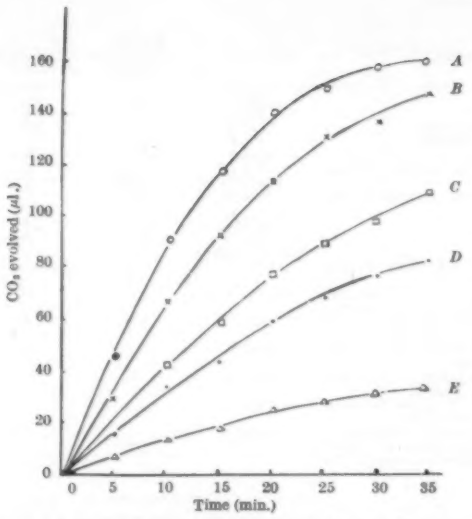
By Dr. B. W. TOWN, E. D. WILLS
AND
Prof. A. WORMALL
Dept. of Biochemistry and Chemistry, Medical College of St. Bartholomew's Hospital, London

WHEN injected intravenously, suramin (synonyms: 'Antrypol': Bayer 205; 'Germanin': Fourneau 309) quickly effects the removal of trypanosomes from the blood and tissues of man and other animals suffering from sleeping sickness due to *Trypanosoma gambiense* or *T. rhodesiense* infections, if the infection is not too far advanced. The precise way in which suramin exerts its specific action on the trypanosome or on the defence mechanisms of the host or on both is still unknown, although several theories have been advanced[1].

One possible explanation is that the drug combines with or otherwise inhibits enzymes in the trypanosome which are necessary for the normal metabolic changes in that organism. Trypanosomes consume considerable quantities of carbohydrates; it was found, for example, that trypanosomes can be kept alive *in vitro* much longer if glucose is added to the medium[2]. The rapid utilization of oxygen by the trypanosomes can easily be demonstrated by manometric methods, or more simply by keeping small samples of citrated blood from infected sleeping sickness patients and suitable controls out of contact with oxygen for a short time; the trypanosome-containing blood often becomes noticeably darker than the controls, owing to deoxygenation of the oxyhæmoglobin by the trypanosomes.

Any inhibition of this comparatively vigorous oxidative metabolism in the trypanosome might be expected to reduce its reproductive capacity and/or its resistance to the attack of the body defence mechanisms, and a knowledge of the action of trypanocidal drugs on enzymes might prove very useful. We are therefore studying the action of suramin on various enzyme systems, including those of the trypanosome, to determine whether concentrations of the drug similar to those reached in the blood of injected animals, or inside the trypanosome, are likely to prove toxic to any particular enzymes. So far we have largely confined our tests to the yeast enzymes concerned with carbohydrate metabolism and some other enzymes selected for particular reasons.

Previous investigators have studied the action of suramin on a few enzymes. In relatively high concentrations (0·007 *M*, that is, 1 per cent) the drug inhibits trypsin[3], and in $1{\cdot}75 \times 10^{-4}$ *M* concentrations it was found to be toxic to the enzyme fumarase but not to urease[4]. Acceleration of post-mortem lactic acid production in muscle and liver has been reported[5], but retardation of blood glucolysis[6]. Hyaluronidase

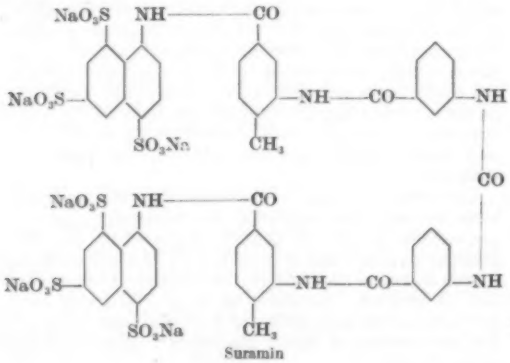


Inhibition of urease by suramin at *p*H 5·0. (Soya bean urease; $2·3 \times 10^{-2}$ *M* urea; enzyme and drug in contact for 30 min. before suramin added)

A, no suramin; *D*, *M*/5,000 suramin
B, *M*/15,000 suramin *E*, *M*/3,000 ,,
C, *M*/7,500 ,,

has very recently[7] been found to be remarkably sensitive to the drug; 85 per cent inhibition of the enzyme is effected by 7×10^{-5} *M* suramin and 15 per cent by 7×10^{-7} *M*.

In our experiments we have found that although suramin has no inhibitory action on urease at *p*H 7·5 (thus confirming previous work[4]), marked inhibition occurs at *p*H 5; at this latter *p*H a final concentration of $3·3 \times 10^{-4}$ *M* suramin gives 90 per cent inhibition, and 7×10^{-5} *M* suramin inhibits to the extent of 25–65 per cent (varying with the time of contact of drug and enzyme). A few typical results of these experiments are shown in the accompanying graph. The mechanism of this inhibition is still under investigation; but our results suggest that the suramin acts by competitive inhibition. This may be related to the presence of a urea structure in suramin, but it is also possible that the action of the drug on urease and other enzymes, like the combination with serum and other proteins[8], and the persistence of the drug in the animal body[9], is largely determined by the sulphonic acid groups of suramin.



Suramin

Very recently we learned that Dr. Madinaveitia, of Imperial Chemical Industries, Ltd., has also been carrying out investigations with suramin and urease, and that he has obtained results similar to our own.

Suramin combines with a variety of protein,[10], particularly at *p*H 5 or in more acid solutions[6]. It might be expected, therefore, that most enzymes would be inhibited by suramin in acid solution, but this is not so. The hydrolysis of plasma proteins by pepsin at *p*H 2 is not inhibited by 0·001 *M* suramin; the fact that in precisely the same buffer solution at *p*H 5 urease is strongly inhibited by suramin, whereas invertase is unaffected by the drug, is indicative of the specificity of the inhibition. Furthermore, we have found that there are many enzymes which are not significantly inhibited by suramin.

In our experiments, trypsin (Harrington Bros., Ltd.) has been found to be much more sensitive to the drug than was previously[3] reported; for example, 0·001 *M* concentrations of suramin gave 30 per cent inhibition of the hydrolysis of casein, and 0·0005 *M* suramin gave 20 per cent inhibition at *p*H 8·9 and 30°. Inhibition of this enzyme may be due to the similarity between the —NH—CO—NH— structure of suramin and the peptide linkage of proteins, but further work will be needed before this is fully established. Tests are now being carried out to determine the effect, on urease, trypsin and other enzymes, of several suramin analogues and similar compounds.

Since the metabolism of trypanosomes is largely concerned with carbohydrates, we decided to study, by manometric methods, the action of suramin on the carbohydrate-metabolizing enzymes of yeast. We have found that the drug strongly inhibits the fermentation of glucose by yeast juice, concentrations greater than $2·0 \times 10^{-5}$ *M* giving 100 per cent inhibition. This concentration is considerably less than that which is maintained in the plasma of a rabbit for several hours or days after the injection of an amount of the drug equivalent to that used clinically; even after four days, for example, the level may still be 3·5 mgm. of suramin/100 ml. of plasma (equivalent to $2·5 \times 10^{-5}$ *M*)[11]. Our study of the effect of the drug on the individual enzymes of yeast is not yet complete, but it is hoped that it will provide a clue to the enzymes in the trypanosome which are likely to be affected by the drug.

We are grateful to the Medical Research Council for a grant covering the expenses of these investigations. Thanks are also tendered to Dr. M. Dixon for samples of fructose diphosphate and adenosine triphosphate, to Dr. A. Spinks (of Imperial Chemical Industries, Ltd.) for samples of several suramin analogues, and to Miss Barbara Hume for help with some of the manometric experiments.

[1] See review of the literature by Findlay, G. M., "Recent Advances in Chemotherapy" (J. and A. Churchill, 2nd edition, 1939).
[2] Yorke, W., Adams, A. R. D., and Murgatroyd, F., *Ann. Trop. Med. Parasitol.*, **23**, 501 (1929); **24**, 115 (1930).
[3] Bellinsohn, A., *Zhurnal Exp. Biol. Med.*, **11**, 52 (1929); cited from *Chem. Abstr.*, **24**, 1427 (1930).
[4] Quastel, J. H., *Biochem. J.*, **25**, 1121 (1931).
[5] Fürth, O., Scholl, R., and Herrmann, H., *Wien. klin. Woch.*, **45**, 1012 (1932).
[6] Stuber, B., and Lang, K., *Biochem. Z.*, **179**, 70 (1926); cf., however, Tchernikofsky, P., and Nattan-Larrier, R., *C.R. Soc. Biol.*, **126**, 1070 (1937).
[7] Beiler, J. M., and Martin, C. J., *J. Biol. Chem.*, **174**, 31 (1948).
[8] Wilson, E. J., and Wormall, A. (in the press).
[9] Spinks, A., *Biochem. J.*, **42**, 109 (1948).
[10] Boursnell, J. C., and Wormall, A., *Biochem. J.*, **33**, 1191 (1939); Dewey, H. M., and Wormall, A., *ibid.*, **40**, 119 (1946).
[11] Dangerfield, W. G., Gaunt, W. E., and Wormall, A., *Biochem. J.*, **32**, 59 (1938); cf. also Vierthaler, R. W., and Boselli, A., *Arch. Schiffs-u. Tropenhyg.*, **43**, 149 (1939); Spinks, A., reference 9.

DENSITY OF HEAVY WATER

By Prof. TSING-LIEN CHANG
AND
LÜ-HO TUNG
Chemistry Department, National Tsing Hua University, Peiping

THE density of heavy water was accurately determined by Stokland, Ronaess and Tronstad[1] in the temperature range 10–27°. Measurements were extended to 50° by Chang and Chien[2], and later by Wirtz[3]. Recently, we have further extended the measurement up to the boiling point of heavy water.

A 16-ml. quartz pycnometer consisting of a bulb with a short stem of 0·5-mm. calibre and a ground-joint cap was used. A thermostat kept the temperature constant within 0·01°. Special precautions were taken regarding the pycnometry, thermometry, purification of water, avoidance of contact with atmospheric moisture, reduction of the weighings to vacuum, and volume correction for the thermal expansion of vitreous quartz. In order to make sure of the accuracy of our measurements, we have determined the density of ordinary water between 50° and 100° and found that the results agree with Thiessen's data[4] within three units in the fifth decimal place.

Two ampoules of heavy water of different concentrations supplied by Norsk Hydro-Elektrisk Kvaelstof A/S were distilled under vacuum direct into the pycnometer. The mole percentage of D_2O was calculated[5] from its density ratio d^{25}_{25} in comparison with ordinary water at 25°. The Norwegian heavy water is known[6] to contain 0·32 weight per cent D_2O^{18}. Three series of measurements were carried out on samples containing 99·71–99·77 mol. per cent D_2O at intervals of 5° between 25° and 100° with special attention to the temperature range above 50°. The density ratio d^{25}_{25} of the sample was determined before and after each series of measurements.

From the density values so obtained are subtracted those of ordinary water at the corresponding temperatures. The difference of density between heavy water and ordinary water is obtained by linear extrapolation. In the extrapolation to 100 per cent D_2O with normal isotopic composition of oxygen, the excess of the oxygen-18 water is included in the D_2O content. The possible error so introduced will not affect the fifth decimal place of the density value.

The density differences at various temperatures were smoothed by the graphical method. The mean deviation of the measured values from those of the smoothed curve is 0·000 02 gm./ml. Using Swift's value[5] for 5° and Tronstad's values[1] between 10° and 25°, we have prepared the accompanying table for the density of heavy water (d_{D_2O}) in the liquid state, covering the complete temperature range between its freezing and boiling point. Considering the errors from different sources, we believe that our density values are accurate to 0·000 05 gm./ml. The density of ordinary water (d_{H_2O}) is also given for comparison, together with the density ratio of heavy and ordinary water. This ratio has also a tendency to pass over a maximum as predicted by Chang and Chien. The temperature for such a maximum seems to lie not far above the boiling point.

The density values in the temperature range between 30° and 50° formerly determined in this laboratory[2] are slightly too high, and those of Wirtz too low, while Bridgman's approximate values[7] for 60° and 80°, which represent the only known data above 50° up to the present, are much too high.

Experimental details will appear elsewhere.

Temperature °C.	d_{H_2O} gm./ml.	d_{D_2O} gm./ml.	$d_{D_2O} - d_{H_2O}$ gm./ml.	$\frac{d_{D_2O}}{d_{H_2O}}$
3·8	1·00000	1·10538	0·10538	1·10538
5	0·99999	10555	556	556
10	9973	10595	622	625
11·2	9961	10596	635	639
15	9913	10583	670	678
20	9823	10530	707	726
25	9707	10440	733	764
30	9568	10319	751	798
35	9406	10169	763	827
40	9225	09992	767	851
45	9024	9790	766	871
50	8807	9565	758	888
55	8573	9319	746	902
60	8324	9054	730	913
65	8059	8771	712	924
70	7781	8471	690	933
75	7489	8154	665	940
80	7183	7821	638	946
85	6865	7472	607	950
90	6534	7109	575	954
95	6192	6732	540	957
100	5838	6342	504	960
101·4	5736	6229	493	960

[1] Stokland, K., Ronaess, E., and Tronstad, L., *Trans. Farad. Soc.*, **35**, 312 (1939).
[2] Chang, T. L., and Chien, J. Y., *J. Amer. Chem. Soc.*, **63**, 1709 (1941).
[3] Wirtz, K., *Naturwiss.*, **30**, 330 (1942): *Physik. Z.*, **43**, 465 (1942).
[4] "International Critical Tables", **3**, 24 (1928). Stähler, "Handbuch der Arbeitsmethoden in der anorganischen Chemie", **3/1**, 51 (1913).
[5] Swift, E., Jr., *J. Amer. Chem. Soc.*, **61**, 198 (1939).
[6] Tronstad, L., and Brun, J., *Trans. Farad. Soc.*, **34**, 766 (1938).
[7] Bridgman, P. W., *J. Chem. Phys.*, **3**, 597 (1935).

MATHEMATICAL ASSOCIATION

ANNUAL MEETING

FOR the first time, the annual meeting of the Mathematical Association was held outside London; at the invitation of the Association's Midland Branch, and with the generous co-operation of the University of Birmingham, which provided lecture theatres and hostel accommodation, the Association met at Birmingham during April 20–23.

Duties abroad prevented the president, Sir Harold Spencer Jones, Astronomer Royal, from attending the meetings. In his absence, Mr. A. W. Siddons presided over the business meeting on April 21, at which Mr. A. Robson, until recently senior mathematical master at Marlborough College, was elected president for the forthcoming year. Sir Harold Spencer Jones will give his presidential address next year, Mr. Robson having agreed to give his address this year to fill the gap. Under the title, "How they Learnt, 1600–1850", Mr. Robson traced the development in content and treatment of the mathematical curriculum in English schools during this period, based on a study of text-books and school records, particularly those relating to Christ's Hospital. Mr. Robson's investigations show that the common view that mathematics was taught entirely as an academic subject, with little relation to practical applications, is not wholly correct. Prof. S. Brodetsky, formerly of the University of Leeds, then gave a lecture on nomography, showing how the solution of equations and the performance of various types of calculation can be carried out rapidly and with reasonable

accuracy by means of the alignment of points on scale-carrying lines. For the remainder of April 21, a programme of excursions and entertainment was provided.

The morning of April 22 was occupied with two lectures: Dr. W. M. Hampton outlined the mathematical investigations which have been made into certain practical problems in glass-working, showing a very fair correspondence between theory and practice. Prof. R. Peierls, of the University of Birmingham, spoke on "Mathematics—Dead or Alive?", and emphasized a principle which has always been fundamental in the Association's policy, that mathematics cannot successfully be taught as a dead subject, but only as a living organism in contact with present-day developments, whether these be in the applications of mathematics to problems of importance in other sciences or in the extension of mathematical knowledge itself by current research.

Two valuable discussions filled the afternoon session. In opening the discussion on "A Realistic View of Main School Geometry", Mr. C. V. Durell proclaimed that geometry is a physical science, not a pattern of logical relations between mathematical abstractions; but Mr. Robson, following Mr. Durell, maintained that a logical system of some kind must be developed in the later years of the school geometry course. In the following open discussion, there appeared to be some feeling among the younger teachers that the reaction against Euclid in the schools may be in danger of going too far. The other discussion, on "Alternatives to School Certificate Mathematics, with reference to Secondary Modern Schools", opened by Mrs. E. M. Williams (City of Leicester Training College) and Mr. R. C. Lyness, a Ministry of Education inspector, reflected the Association's close attention to the problem of mathematical teaching in the new Modern School, where there is a danger that content and method may be too closely a copy of content and method in the Grammar School, instead of being firmly based and developed on the functional needs of the Modern School.

In the evening, Mr. J. A. Petch, secretary of the Joint Matriculation Board, spoke on a subject of vital interest to teachers, "Statistical Treatment of Examination Marks". Mr. Petch described the mathematical methods used in dealing with large-scale external examinations in order to minimize variations, to standardize the markings of a panel of examiners who share the assessment of scripts in one subject, and to set up a standard of comparison between markings in different subjects. His audience welcomed his demonstration of the skill, care and patience devoted to the assessment of the merits of the School Certificate candidate.

On the morning of April 23, a first step was made on a programme which the Association hopes to follow up in later meetings, by getting speakers from outside Great Britain to deal with aspects of mathematical education in their countries. On this occasion, Mr. B. T. Gilroy, of New South Wales, and Mr. R. G. Keats, of South Australia, outlined the system of mathematical teaching in the secondary schools and universities of Australia. Dr. H. C. Christofferson, of Oxford, Ohio, described the ideals which inspire the teachers of mathematics in the high schools of the United States; members of the Association supported his plea for a complete fusion of theory with practice, appreciated his illustrations of detail, and relished his fund of American anecdote.

A NEW FOSSIL GYMNOSPERMOUS 'OVARY'

THE discovery of a new type of many-seeded fruit body from the Lower Carboniferous of Scotland is a matter of more than local palæobotanical interest. The publication by Prof. John Walton of the full description of *Calathospermum scoticum* (*Trans. Roy. Soc. Edin.*, **61**, 719; 1949), which has been awaited since the preliminary account in 1940[1], is therefore most welcome, although it is difficult to withhold a protest that any learned society, so long after the end of the War, should subject important scientific work to the treatment recorded in the superscription "MS. received May 10th, 1947. Read May 3rd, 1948. Issued separately Feb. 11th, 1949."

Calathospermum scoticum consists of isolated fruit bodies of large size (up to 24 mm. × 45 mm.), shaped like a tulip and each consisting of a cupule divided into six segments which surround either a central mass of stalks or an equivalent number of stalked ovules. Compared with other known many-seeded cupules (*Gnetopsis* and *Calathiops*), *Calathospermum* is the first to be discovered of Palæozoic age in which the mode of arrangement of the ovules inside the cupule can be studied, thereby contributing some very interesting comparative facts to place beside the better known but much more recent *Caytonia*. The stalks in *Calathospermum* are partly borne on the margins of the cupule segments but also on a quadripartite central column to which some twenty-four of them may be attached. Each stalk has a central vascular strand which is continued into the integument of the ovule and out into its appendages. The latter consist of nine terete apical projections of considerable length which terminate the orthotropous ovules. In the form of these appendages and in other characters the ovules themselves resemble very closely those of *Salpingostoma dasi* described by Gordon in 1941[2], although they are thought to be specifically distinct. *Salpingostoma*, interestingly enough, is itself the oldest structurally preserved seed which can be assigned with certainty to the Pteridosperms.

In attempting to interpret the presence of two states of the fruit bodies, those containing ovules on badly preserved (and therefore perhaps immature) stalks and those containing well-preserved stalks but no ovules, the suggestion is made that the latter are probably in the more advanced developmental state. It is thought that, as the seeds ripened, their stalks may have elongated and extruded them from the cupule, after which they became detached. From details observed in the histology of the cupule segments it is thought that these may have opened out in a perianth-like manner during extrusion of the seeds, although in the water-logged condition preceding fossilization they had again closed.

The fruit body appears to have been borne on the end of a stalk containing a single crescentic vascular strand. It is therefore concluded that they were foliar and not axial appendages.

For the non-specialist reader a valuable commentary on these facts will be found in the recently published Symposium on the Evolution and Classification of the Gymnosperms held in Chicago in December 1947. Prof. H. N. Andrews's paper[3] in particular supplies a very valuable background in his survey of existing knowledge of Pteridosperms in general, while Prof. B. Sahni[4], by giving details of

another new Gymnospermous group, the Jurassic Pentoxyleæ, in which naked seeds with fleshy integuments are clustered directly on to a cauline cone axis totally devoid of any trace of leaf-like appendages, provides a wholesome corrective against the hasty generalizations which *Calathospermum* by itself might arouse in the unwary. Both *Calathospermum* and the Pentoxyleæ are, however, of first-rate theoretical importance in the phylogeny of the Gymnosperms, and both, therefore, merit the attention of a general botanist.

[1] Walton, J., "Introduction to the Study of Fossil Plants" (London, 1940).
[2] Gordon, W. T., *Trans. Roy. Soc. Edin.*, **60**, 427 (1941).
[3] Andrews, H. N., *Bot. Gaz.*, **110**, 13 (1948).
[4] Sahni, B., *Bot. Gaz.*, **110**, 47 (1948).

EUROPEAN CORN BORER IN NORTH AMERICA

THE European corn borer (*Pyrausta nubilalis*) was first found in the United States in 1917, among sweet corn near Boston, Mass., where it was infesting an area of at least 100 square miles. It was later found that the insect was also present at the same time near St. Thomas, Ontario. The actual date or year of entry of this dangerous pest into North America is uncertain, but circumstantial evidence points to its occurrence among broom-corn imported from Hungary or Italy between 1909 and 1914.

The insect is among the most threatening of all pests of Indian corn (or maize); accumulated knowledge shows that its eradication is not possible, but various cultural practices can be adopted so that there results a reduction in the losses caused by the insect. According to W. A. Baker and W. G. Bradley, entomologists of the U.S. Bureau of Entomology and Plant Quarantine, the damage caused by the borer in the United States in 1945 was estimated at 36,700,000 dollars. In a recent publication by these two entomologists* they state that infested areas extend all down the east coast and across the continent to districts west of the Great Lakes. The favourite plant host in America, as in Europe, is Indian corn (maize), but the insect also attacks beans, soybean, millet, oats, potatoes and some other cultivated crops. Garden flowers are also infested, notably dahlias, gladioli, zinnias, chrysanthemums and various weeds that grow among or bordering the maize crop. Among the Lakes States the corn borer is single-brooded and feeds almost entirely on maize, whereas in the southern and eastern parts of the infested region two or even three broods prevail, and the insects affect a wide range of different plants. The injuries it causes are effected during the larval stages when it tunnels into the stalk, main stem or mid-rib of its host-plant, as the case may be. As a result of the damage thus caused, much of the nutriment is cut off from the ear or flowering part, which weakens or flags and breaks.

As regards methods of controlling the borer, the indigenous insect parasites have proved of no avail. They number twenty-four different species, yet their combined activities have resulted in the destruction of only a fraction of 1 per cent of the borer. Large numbers of foreign parasites have been introduced from Europe and have established themselves, but it is premature to state whether they will prove to be effective controlling agents. At the present time the corn borer can be best controlled by utilizing or destroying all parts of infested plants before any of the insects they may contain are able to change into the adult or moth stage. Feeding affected crops to livestock either directly from the field or as silage is a valuable method. In other cases deep ploughing beneath the soil or complete burning of all infested vegetation before the spring when the moths appear is recommended. Any method that leaves behind living borer caterpillars among the plant residues merely provides for the infestation to go on during the following year. The use of insecticidal sprays containing D.D.T. or other toxic agents has been recommended for use during the period when the eggs are hatching, in order to destroy the young caterpillars.

* U.S. Department of Agriculture. Farmers' Bulletin No. 1548: The European Corn Borer; its Present Status and Methods of Control. Revised edition, by W. A. Baker and W. G. Bradley. Pp. 46. (Washington, D.C.: Government Printing Office, 1948.) 15 cents.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 9

ROYAL GEOGRAPHICAL SOCIETY (at Kensington Gore, London, S.W.7), at 5 p.m.—Prof. S. W. Wooldridge and Mr. S. H. Beaver: "Land Use and Surface Mineral Working in Britain".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. F. J. Cole: "Aspects of Biological Discovery, 2, Circulation of the Blood".*

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "Graphical Methods in Teaching Electrical Engineering (including Radio)" (to be opened by Mr. S. N. Ray).

Tuesday, May 10

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5 p.m.—Mr. Tom Harrisson: "Human Studies in Central Borneo, 1945–49".

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Prof. D. V. Glass: "The Application of Social Research" (Inaugural Lecture).*

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.8), at 5 p.m.—Scientific Papers.

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. W. Barr and Mr. J. Erskine: "The Manufacture and Use of Stainless-Clad Steel".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. Jacques Tréfouël (Paris): "Some Advances in Chemotherapeutic Research at the Pasteur Institute".*

ILLUMINATING ENGINEERING SOCIETY (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Annual General Meeting; at 6.30 p.m.—An Address by Monsieur L. Gaymard.

Wednesday, May 11

INSTITUTE OF FUEL, NORTH-WESTERN SECTION (at the Engineers' Club, Albert Square, Manchester), at 11 a.m.—Conference on "Combined Heat and Power Supplies".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. Robert Broom, F.R.S.: "South Africa's Contribution to our Knowledge of Man's Evolution".

UNIVERSITIES FEDERATION FOR ANIMAL WELFARE (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. Jean-Paul Harroy: "Nature Protection".*

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. F. Morton: "Examination of Crude Oils in relation to Geological Formations".

PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Discussion on "The Use of Thermodynamic Diagrams in Industry" (to be opened by Prof. D. M. Newitt, F.R.S.).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. E. K. Rideal, F.R.S.: "How Crystals Grow".

Thursday, May 12

COUNCIL FOR THE PRESERVATION OF RURAL ENGLAND (at the Royal Institute of British Architects, 66 Portland Place, London, W.1), at 2.30 p.m.—Annual General Meeting.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. H. Raistrick, F.R.S.: "A Region of Biosynthesis" (Bakerian Lecture).

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—**Scientific Papers.**

UNIVERSITY OF LONDON (in the Great Hall, King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. V. Gordon Childe: "Social Worlds of Knowledge" (Hobhouse Memorial Lecture).*

CHEMICAL SOCIETY, HULL BRANCH (joint meeting with the University College Scientific Society, in the Science Lecture Theatre, University College, Hull), at 6 p.m.—Prof. A. R. Todd, F.R.S.: "The Mechanism of Drug Action".

CHEMICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 7.15 p.m.—Dr. E. Lederer: "The Chemistry and Biochemistry of some Mammalian Secretions and Excretions".

Friday, May 13

PHYSICAL SOCIETY, OPTICAL GROUP (in the Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3 p.m.—Eighth Annual General Meeting; at 3.15 p.m.—Mr. C. E. Coulman and Mr. G. R. Petrie: "Notes on the Designing of Aspherical Magnifiers for Binocular Vision"; Lecture by Monsieur André Maréchal.

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at the Senate House, London, W.C.1), at 5.30 p.m.—Prof. A. C. Pigou: "Wage Statistics and Wage Policy" (Stamp Memorial Lecture).*

Saturday, May 14

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 3 p.m.—Mr. M. D. Vernon: "The Significance of the Individual in the Social Group".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

EXPERIMENTAL OFFICERS at the Atomic Energy Research Establishment, Ministry of Supply—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2529 (May 13).

PHYSICIST—The Secretary, Romford Group Hospital Management Committee, Oldchurch Hospital, Romford, Essex (May 14).

SENIOR ASSISTANT IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING, a SENIOR ASSISTANT IN THE ELECTRICAL ENGINEERING DEPARTMENT, and a SENIOR ASSISTANT IN THE DEPARTMENT OF APPLIED CHEMISTRY—The Principal, Northampton Polytechnic, St. John Street, London, E.C.1 (May 14).

TEACHER OF ELECTRICAL ENGINEERING, a TEACHER OF PHYSICS, and a TEACHER OF BUILDING AND STRUCTURAL DESIGN—The Principal, College of Technology, Belfast (May 14).

SENIOR ASSISTANT TO TEACH CIVIL AND MECHANICAL ENGINEERING subjects to Honours Degree standard—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (May 14).

LECTURER IN PHYSICS AND PHYSICAL CHEMISTRY at Birkenhead Technical College—The Director of Education, Education Offices, 63 Hamilton Square, Birkenhead (May 14).

LECTURER IN THE DEPARTMENT OF CHEMISTRY, and a LECTURER IN THE DEPARTMENT OF PHYSICS AND MATHEMATICS, Liverpool College of Technology—The Director of Education, 14 Sir Thomas Street, Liverpool 1 (May 14).

REGIONAL DIRECTOR in the County Extension and Advisory Service of the College, an ASSISTANT COUNTY ORGANISER, an ASSISTANT LECTURER IN AGRICULTURAL ENGINEERING AND SURVEYING, and a LECTURER IN HORTICULTURE—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (May 15).

SCIENTIFIC OFFICER (Chemist) in the Food Infestation Control Section in Glasgow of the Department of Agriculture for Scotland—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting P.271/49A (May 16).

ELECTRICAL ENGINEER (Third Assistant grade), an ELECTRICAL ENGINEER (General Assistant grade), a MECHANICAL ENGINEER (Second Assistant grade), a PHYSICIST (Second Assistant grade), a PHYSICIST (General Assistant grade), and a CHEMIST (Second Assistant grade), in the Laboratory at Leatherhead—The Director of Establishments, British Electricity House, Great Portland Street, London, W.1 (May 16).

PRINCIPAL SCIENTIFIC OFFICER to control research and development of radio and radar navigation devices and aircraft approach and landing aids, a PRINCIPAL SCIENTIFIC OFFICER to control research and development of radio communication systems, etc., and a SENIOR SCIENTIFIC OFFICER for the development of components for new radio equipments, in the Ministry of Supply, London—The Secretary, Civil Service Commission, Scientific Branch, 27 Grosvenor Square, London, W.1, quoting No. 2520 (May 18).

RESEARCH ASSISTANT (Grade II) IN THE LIBRARY—The Director and Secretary, Science Museum, South Kensington, London, S.W.7 (May 21).

LECTURER and an ASSISTANT LECTURER IN GEOLOGY—The Registrar, University College, Singleton Park, Swansea (May 28).

ENTOMOLOGIST to the West Indies Cacao Research Scheme, Trinidad—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (May 28).

RESEARCH OFFICER—Heat Laboratory (Ref. No. 1918), and a RESEARCH OFFICER—Wool Research Laboratory (Ref. No. 1919), in the Division of Physics, Council for Scientific and Industrial Research, Sydney—The Chief Scientific Liaison Officer, Australian Scientific Research Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (May 28).

LECTURER IN ZOOLOGY, and an ASSISTANT NATURALIST in the Dove Marine Laboratory—The Registrar, King's College, Newcastle-upon-Tyne (May 28).

LECTURER IN ELECTRONICS—The Head of the Electrical Engineering Department, City and Guilds College, Exhibition Road, London, S.W.7 (May 30).

GRADUATES (preferably those who have taken Mathematics or Physics to an advanced stage) for Junior and Senior positions in the New Zealand Meteorological Service—The Office of the High Commissioner for New Zealand, 415 Strand, London, W.C.2 (May 30).

LEWIS CAMERON FELLOW and LECTURER IN THE DEPARTMENT OF BACTERIOLOGY—The Secretary, The University, South Bridge, Edinburgh 8 (May 31).

RESEARCH ASSISTANTS (with good honours degree in Physical Chemistry) for work on the physical and chemical aspects of selective flotation, a LECTURER IN MINING, and a LECTURER IN THE EXTRA-MURAL AND SOCIAL STUDIES DEPARTMENT—The Registrar, The University, Leeds 2 (May 31).

CHAIR OF INDUSTRIAL METALLURGY, and the SECOND CHAIR OF CHEMICAL ENGINEERING—The Secretary, The University, Birmingham 3 (May 31).

READERSHIP IN PHYSICAL AND INORGANIC CHEMISTRY at Guy's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 1).

READER or SENIOR LECTURER IN ECONOMIC GEOGRAPHY—The Registrar, The University, Manchester 13 (June 3).

SUPERINTENDING ANTHROPOLOGIST, Department of Anthropology, Calcutta—The High Commissioner for India, General Department, India House, Aldwych, London, W.C.2, quoting No. 446.E (June 11).

LECTURER (Grade II) IN TOOL ENGINEERING AND METROLOGY, and a LECTURER (Grade II) IN INDUSTRIAL STATISTICS—The Secretary, The University, Birmingham 3 (June 15).

TUBE INVESTMENTS RESEARCH FELLOWSHIP IN THE DEPARTMENT OF ENGINEERING PRODUCTION—The Secretary, The University, Birmingham 3 (June 15).

ENGLISH ELECTRIC COMPANY BURSARIES IN HYDRO-POWER ENGINEERING—The Deputy Registrar, City and Guilds College, Exhibition Road, London, S.W.7 (June 30).

ASSISTANT PROFESSOR OF PHARMACOLOGY in Farouk I University, Alexandria—The Director, Egyptian Education Bureau, 4 Chesterfield Gardens, London, W.1 (June 30).

LECTURER IN CHEMISTRY—The Warden and Secretary, Royal Free Hospital School of Medicine, 8 Hunter Street, London, W.C.1.

DEPARTMENTAL or UNIVERSITY DEMONSTRATOR for Research in Agricultural Production and Farm Organisation, and a DEPARTMENTAL or UNIVERSITY DEMONSTRATOR for Market Research and Analysis—The Secretary, Agricultural Economics Research Institute, Parks Road, Oxford.

EDUCATION LECTURER IN THE DEPARTMENT OF HYGIENE AND PUBLIC HEALTH—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

HISTOLOGICAL TECHNICIAN for cancer research work in the Laboratory of the Department of Anatomy—The Secretary and Registrar, The University, Bristol 8.

LECTURER IN THE DEPARTMENT OF MATHEMATICS, and a SENIOR ASSISTANT LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING AND PHYSICS—The Principal, Borough Polytechnic, Borough Road, London, S.E.1.

BURSARIES (3) for research in Physical Chemistry, tenable at the Imperial College of Science and Technology—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

LABORATORY TECHNICIAN to assist with a fundamental research programme on the physics of rubber—The Director of Research, British Rubber Producers' Research Association, 48 Tewin Road, Welwyn Garden City, Herts.

DIRECTOR OF THE WEST AFRICAN BUILDING RESEARCH ORGANISATION—The Under-Secretary of State, Colonial Office (Research Department), Sanctuary Buildings, Great Smith Street, London, S.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Cérémonies de X^e anniversaire de la mort de Lord Rutherford. Organisées par la Fédération mondiale des travailleurs scientifiques, l'Association française des travailleurs scientifiques, le Syndicat national de l'enseignement supérieur et de la recherche scientifique. Pp. 68+6 plates. (London: World Federation of Scientific Workers, 1947.) [2911

British Standard 522:1948. Orthocresol, Metacresol and Paracresol. Pp. 16. 2s. net. British Standard 523:1948. Phenol. Pp. 16. 2s. net. British Standard 524:1948. Refined Cresylic Acid. Pp. 20. 2s. 6d. net. (London: British Standards Institution, 1948.) [2911

Catalogues

Catalogue of New Books on Electrical Engineering, Radio and Electronics. Pp. 24. (London: H. K. Lewis and Co., Ltd., 1948.)

Type 903A Oil Diffusion Pump and Combination Baffle Valve. (Leaflet B/903A/1.) Pp. 4. Edwards (Philips Type) Cold Cathode Ionisation Gauge Model 3. (Leaflet D20/3-1.) Pp. 4. (London: W. Edwards and Co., Ltd., 1948.)

A Catalogue of Books of English Literature and History printed after 1700, together with Books from Modern Presses, etc. (No. 661.) Pp. 76. (London: Bernard Quaritch, Ltd., 1948.) 6d.

Marmite Yeast Extract in Medicine and Dietetics. Revised edition. Pp. 16. (London: Marmite Food Extract Co., Ltd., 1948.)

A Catalogue of Books on Archæology and Folklore, Arts and Crafts, History, Naval History and Shipping, Sport, Music and Theatre, etc. (No. 694.) Pp. 122 (London: Francis Edwards, Ltd., 1948.)